Sun. May 26, 2019

[E] Oral | U (Union)：Union

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 101 1F

[U-01] JpGU-AGU-EGU Great Debate: Impact of research assessment and going forward

convener:Kazuaki Hori(Department of Geography, Graduate School of Environmental Studies, Nagoya University), Denis-Didier Rousseau(CNRS - ENS), Jonathan L Bamber(member), Chairperson:Yasuhiro Murayama(NICT)

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC

[U01-01] Panel discussion about research assessment

*Kazuaki Hori[1] (1.Department of Geography, Graduate School of Environmental Studies, Nagoya University)

[E] Oral | U (Union)：Union

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 101 1F

[U-02] Advancing workplace: progress, challenges and strategies for improvement

convener:Chiaki T. Oguchi(Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University), Rie Hori, S.(Department of Earth Science, Faculty of Science, Ehime University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Claudia Jesus-Rydin(European Research Council), Chairperson:Rie Hori, Chiaki Oguchi

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[U02-01] Managing Diversity and Inclusiveness

*Jessica Federman[1] (1.California State University, Dominguez Hills)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[U02-02] Adina Paytan 12:36 PM (0 minutes ago)
to me **Where Have All the Women Gone?**

★Invited Papers

*Adina Paytan[1] (1.University of California Santa Cruz)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[U02-03] Gender balance and diversity in the ocean and geosciences: IODP, research cruise, and laboratories

*Natsue Abe[1] (1.R&D Center for Ocean Drilling Science Japan Agency for Marine-Earth Science and Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[U02-04] Problem in paternity leave

*Yukihiro Takahashi[1] (1.Department of Cosmosciences, Graduate School of Science, Hokkaido University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[U02-05] Challenges in teaching interactive lectures with high student diversity using student response systems

★Invited Papers

*Thomas Parkner[1], Verena Pietzner[2] (1.University of Tsukuba, 2.University of Oldenburg)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[U02-06] **The AGU Ethics and Equity Center: New Resources for Advancing Workplace Excellence**

Brooks Hanson[1], Christine McEntee[1], Robin Elizabeth Bell[1], *Billy M Williams[1] (1.American Geophysical Union)

[J] Oral | O (Public)：Public

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | IC 2F

[O-01] Exploring Buratamori - How to make science accessible

convener:Kazutaka Mannen(Hot Springs Research Institute of Kanagawa Prefecture), Takayuki Ogata(Disaster Prevention Research Center for Island Regions, University of the Ryukyus), Chairperson:Takayuki Ogata

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[O01-01] Lessons from Buratamori – An introduction to the session

★Invited Papers

*Kazutaka Mannen[1] (1.Hot Springs Research Institute of Kanagawa Prefecture)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[O01-02] **The history of Buratamori**

★Invited Papers

*Mikio Hayashi[1] (1.Japan Broadcasting Corporation)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[O01-03] My experience as a geoscientific guide for the NHK-TV program Buratamori

★Invited Papers

*Masato Koyama[1] (1.Shizuoka Univ.)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[O01-04] A Visualized History by Buratamori

★Invited Papers

*Noriko Matsuda[1] (1.Kyoto Prefectural University)

2:45 PM - 3:15 PM JST | 5:45 AM - 6:15 AM UTC

[O01-05] General discussion 1

*Takayuki Ogata[1] (1.Disaster Prevention Research Center for Island Regions, University of the Ryukyus)

[J] Oral | O (Public)：Public

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | IC 2F

[O-01] Exploring Buratamori - How to make science accessible

convener:Kazutaka Mannen(Hot Springs Research Institute of Kanagawa Prefecture), Takayuki Ogata(Disaster Prevention Research Center for Island Regions, University of the Ryukyus), Chairperson:Kazutaka Mannen(Hot Springs Research Institute of Kanagawa Prefecture)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[O01-06] The role of experiment in NHK's entertainment / educational program "Buratamori"

★Invited Papers

*Shintaro Hayashi[1] (1.Akita University Graduate School of Education)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[O01-07] An attempt of field work for middle and high school students to comprehend an “area” in an integrated manner

★Invited Papers

*Takeshi Uemura[1], Shigeyuki Yokoi[2] (1.Osaka Prefectural Otemae Senior High School part-time course, 2.Kaijo Junior and Senior High School)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[O01-08] Desirable way of outreach activities in the Museum,learn by participating in the making process of "Buratamori".

★Invited Papers

*Inoue Motoko[1] (1.Saitama Museum of Natural History)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[O01-09] Methodology of Geoscientific Outreach of “Buratamori”

★Invited Papers

*Takayuki Ogata[1] (1.Disaster Prevention Research Center for Island Regions, University of the Ryukyus)

4:30 PM - 5:00 PM JST | 7:30 AM - 8:00 AM UTC

[O01-10] General discussion 2

*Kazutaka Mannen[1] (1.Hot Springs Research Institute of Kanagawa Prefecture)

[J] Oral | O (Public)：Public

10:15 AM - 11:25 AM JST | 1:15 AM - 2:25 AM UTC | IC 2F

[O-02] Recent Advances in Earth and Planetary Science

convener:Tatsuhiko Hara(International Institute of Seismology and Earthquake Engineering, Building Research Institute), Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Chairperson:Kou Yamada

10:15 AM - 10:50 AM JST | 1:15 AM - 1:50 AM UTC

[O02-01] The challenges of Asteroid Exploration Mission Hayabusa2 and its results up to now

★Invited Papers

*Makoto Yoshikawa[1] (1.Japan Aerospace Exploration Agency)

10:50 AM - 11:25 AM JST | 1:50 AM - 2:25 AM UTC

[O02-02] Earth's core revealed by ultrahigh-pressure experiments

★Invited Papers

*Kei Hirose[1,2] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Department of Earth and Planetary Science, The University of Tokyo)

[J] Oral | O (Public)：Public

11:30 AM - 12:15 PM JST | 2:30 AM - 3:15 AM UTC | IC 2F

[O-03] Poster presentations by senior high school students

convener:Tatsuhiko Hara(International Institute of Seismology and Earthquake Engineering, Building Research Institute), Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kou Yamada(Waseda University), Chairperson:Kou Yamada, Katsuyoshi Michibayashi, Hajime Naruse(Kyoto University), Keiko Konya, Miwa Kuri(東北大学災害科学国際研究所)

11:30 AM - 12:15 PM JST | 2:30 AM - 3:15 AM UTC

[O03-01] Poster presentations by senior high school students

[J] Poster | O (Public) : Public

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_1

[O-03] Poster presentations by senior high school students

convener:Tatsuhiko Hara(International Institute of Seismology and Earthquake Engineering, Building Research Institute), Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kou Yamada(Waseda University)

[O03-P01] Factors of the famine of Aomori in the Edo era viewed from the Hirosaki domain diarty

*Masyu Sakamoto[1], *Mizuha Kamata[1], *Aten Noguchi[1] (1.Ikedagakuen Ikeda Senior High School)

[O03-P02] Visual monitoring and surface wind analyzing clarified the importance of sea and valley wind in causing sudden shower in mountain basin

*Aihisa Kamijo[1] (1.Geoscience Club, Matsumoto Fukashi Senior High School)

[O03-P03] The effect of coastal erosion on Shinmaikohama Beach

*Yuuto Yoshida[1], *Izuki Onoda[1], *Ayaka Saitou[1], *Issei Suzuki[1], *Haruto Komiya[1], *Toshiki Sasaki[1], *Daisuke Baba[1] (1.Fukushima Prefectural Iwaki High school)

[O03-P04] Consideration by Grave seismology

*Yuito Kaji[1], Kosuke Kobayashi[1], Kaname Ishida[1], Yasuhiro Suzuki[1], Kyoichiro Uehara[1] (1.Yashiro High School)

[O03-P05] Analysis of metal ion concentration in the rivers of Yosemite Valley and comparison with Japanese rivers

*Kaname Ishida[1], Noa Harada[1], Michihiko Kondo[1] (1.Yashiro High School)

[O03-P06] Magnetic measurement of basalt dikes in the Sara river of Tsuyama

*Hayate Madokoro[1], *Yuta Emi[1], *Syota Matano[1], *Naoyuki Washida[1] (1.Okayama prefectural Tsuyama High School)

[O03-P07] The Study of Seawalls Combined with Moats

*Toshiatsu Aoki[1] (1.Yokohama Science Frontier High School)

[O03-P08] Relationship between the seismic moment release rate in the Nankai subduction zone and the 2011 Tohoku earthquake

*Yoko Kono[1] (1.Yokohama Science Frontier High School)

[O03-P09] Automation of the self-made pinhole type planetarium projector

*Masami Kanno[1], *Asahi Komori[1], *Haruhito Nakamura[1], Kano Makiyama[1], *Munehiro Asao[1], *Ryo Kakegami[1], Akika Shimizu[1], Tomoka Kawamoto[1] (1.Yokohama Science Frontier High School)

[O03-P10] Capturing Blue-shift of Red Edge using the Spectrum of Earthshine
-The Earth seen from the space-

*Noa Itou[1], *Ayami Yoshino[1] (1.Yokohama Science Frontier High School)

[O03-P11] Observation of Thundercloud

*Ayune Masuda[1] (1.Yokohama Science Frontier High School)

[O03-P12] A Historical Review of the Sky in Yokohama 1965 to 2014

*Rikako akai[1] (1.Yokohama Science Frontier High School)

[O03-P13] Seismic isolation system for furniture

*Tesshin Noma[1], *Syuntaro Hayashi[1] (1.Sakae-Higashi High school)

[O03-P14] How to use soil of school

*Hohoko Asahina[1], Honoka Oinuma[1] (1.Tokyo Metropolitan Tama High School of Science and Technology)

[O03-P15] Measurement of Cloud Cover at Night by Brightness

*Soyoka Okano[1] (1.Tokyo Metropolitan Tama High School of Science and Technology)

[O03-P16] Application of ion-exchange reaction in soil for desalination system

*Yushi Sato[1], Ryota Iizuka[1], Toya Nakano[1] (1.Tokyo Metropolitan Tama High School of Science and Technology)

[O03-P17] Investigation into agricultural utilization by the aluminum removal of the trass

*Yuto Miki[1] (1.Tokyo Metropolitan Tama High School of Science and Technology)

[O03-P18] Earthquake prediction by radio wave noise

*Sou - Yasuda[1], Ryosuke - Kiribuchi[1], Hiromori – Hayashi[1], Rinta - Yamada[1], *Aiku - Tanaka[1] (1.Tokyo Metropolitan Tama High School of Science and Technology)

[O03-P19] Construct quaking models by the geological structure varieties

*Kazuki Sugawara[1], *Hideto Sato[1], Shuya Yamaki[1], Masato Ono[1], Shun Suto[1] (1.Miyagi Rifu high school)

[O03-P20] Fe concentration measurement method in spring water

*Nozomi Kawaharata[1], *Yusuke Oba [1], Yuto Sasaki [1], *Tika Sakuma [1], *Rei Sato[1], *Siratake Kosuke[1], *Riku Sugawara [1], *Masaki Murayama [1] (1.Furukawa Reimi Junior and Senior High School)

[O03-P21] Cause of amateur radio failure in meteor radio observation and its substitution

*Shoki Yashima[1], *Kokoro Abe[1], *Azumi Sato[1], *Sora Endo[1], *Kokomi Sugawara[1] (1.Furukawa Reimei Junior and Senior High School)

[O03-P22] Spectroscopic observation of meteor using diffraction grating

*Soya Ito[1], *Atsuya Sugawara[1], *Tomoki Misao[1], *Shotaro Mino[1] (1.Miyagi Furukawa Reimei Junior and Senior High School)

[O03-P23] Predicting the sea level change in the Ariake bay through analysis of diatoms and pollens

*Ayuto Yamashita[1], *Shino Furuta[1] (1.Kumamoto prefectural Amakusa High School)

[O03-P24] Altering unused irrigation ponds to mitigate flooding, maintain habitats, and reduce maintenance burden

*Rikuto Fukushima[1], Nao Maeda[1], Reo Yoneyama[1], Yuki Takahashi[1], Hiiro Tabata[1], Koutaro Hayashi[1] (1.Hyogo Prefectural Kakogawa Higashi High School)

[O03-P25] Development of the equatorial telescope for from the beginners to the advanced astrophotographer at low cost

*Jun Ikeda[1], *Shimpei Iwasaki[1] (1.Kaijo Senior High School)

[O03-P26] How ripples formation dependence on the size of sand grains and the amplitude of vibration cycle

*Tsuyoshi Enta[1], *Ryutaro Mitsui[1] (1.Kaijo Senior High School)

[O03-P27] Organizing the relation ship of the viscosity of lava flow and the shape of columnar joijnt

*Kanta Takakura[1] (1.Kaijo junior and senior high school)

[O03-P28] Measurement of the geomagnetic horizontal component with a neodymium magnet

*Yushi Miyamoto[1], Hayato Ishiguro[1], Shun Takada[1], Kento Nakayama[1] (1.Sapporo Nihon University Senior High School)

[O03-P29] Relationship between sun elevation and RGB values of sunlight color

*Shun Takada[1], Kotaro Takemura[1], Taio Koizumi[1], Hayato Ishiguro[1] (1.Sapporo Nihon University Senior High School)

[O03-P30] Reserch about Dokuzawa mineral spring on Shimouswa hot spring

*Ryosuke Yanagisawa[1], *Yoshito Momoi[1], *Yoko Kamata[1], *Takumi Kamijyo[1] (1.Naganoken Suwa Seiryo Senior High School)

[O03-P31] Can you predict the weaather when you see the starry sky

*Aoi Takamori[1] (1.Naganoken Suwa Seiryo Senior High School)

[O03-P32] Fossil ophiuroid ossicles and ostracods from the Shimousa Group distributed around Magaki, Mihomura, Ibaraki Prefecture

*Asaka Yokobori[1], *Rin Mita[1] (1.Gunma Prefectural Ota Girls' High School)

[O03-P33] Conservation activities for bivalve fossils by Muroto High School Students

*Shuka Ishitani[1], Miku O̅no[1], Fukuoka Eri[1] (1.Muroto High School)

[O03-P34] Changes in Shinto Festivals in Muroto UNESCO Global Geopark

*Eri Fukuoka[1], Nanami Hashimoto[1], Yui Takemura[1], Hayato Nii[1], Taisei Hamada[1] (1.Muroto High School)

[O03-P35] The Study of Old Tottori sand dunes. Why the sand become hard ? Epilogue

*katsuki takana[1], *ren osaki[1], *ritsuki sugiura[1], satosi arita[1], syogo okayama[1], yuta sunaba[1], aoi hashikawa[1], ken hirooka[1] (1.Tottori Prefectural Tottorihigashi High School)

[O03-P36] Forest education by the making of a clay ball and a moss ball

*Yuna Miyachi[1], Arika Tsuji[1], Yuzuki Kobayashi[1], Sae Takami[1], Tatsuki Morikawa[1], Ryota Yamasaki[1], Yuto Umeda[1], Matsuki Rina[1], Nahoko Kubo[1], Yo Sayama[1] (1.Kyoto Prefectural Sagano High Scool)

[O03-P37] The Roles of Clay Minerals in the Pedosphere of the Woods for Field Practice Owned by Sagano High School

*Nahoko Kubo[1], Yo Sayama[1], Yuna Miyachi[1], Arika Tsuji[1], Sae Takami[1], Yuzuki Kobayashi[1], Yuto Umeda[1], Tarsuki Morikawa[1], Ryota Yamasaki[1], Rina Matsuki[1] (1.Kyoto Prefectural Sagano High School)

[O03-P38] For the development of brand-name products in WFS. ~ Selection of high quality Chamaecyparis and investigation of suitable drying method ~

*Yuzuki Kobayashi[1], Sae Takami[1], Rina Matsuki[1], Ryota Yamazaki[1], Yuto Umeda[1], Tatsuki Morikawa[1], Nahoko Kubo[1], Yo Sayama[1], Arika Tsuji[1], Yuna Miyachi[1] (1.Kyoto Prefectural Sagano High School)

[O03-P39] Grasping the human impact following a forest research and its recovery

*Yo Sayama[1], Yuna Miyachi[1], Arika Tsuji[1], Sae Takami[1], Yuzuki Kobayashi[1], Yuto Umeda[1], Tatsuki Morikawa[1], Ryota Yamasaki[1], Rina Matsuki[1], Nahoko Kubo[1] (1.Kyoto Prefectural Sagano High School)

[O03-P40] Considering the recent landslide disasters in Japan -Movement of water in pedosphere-

*Rina Matsuki[1], Nahoko Kubo[1], Yo Sayama[1], Arika Tsuji[1], Yuna Miyachi[1], Yuzuki Kobayashi[1], Sae Takami[1], Tatuki Morikawa[1], Ryota Yamasaki[1], Yuto Umeda[1] (1.Kyoto Prefectural Sagano High School)

[O03-P41] Comparison of GSI map data with the surveying data by targeting Woods for Field Practice Owned by Sagano High School

Yuto Umeda[1], Tatsuki Morikawa[1], Ryota Yamasaki[1], Rina Matsuki[1], Nahoko Kubo[1], Yo Sayama[1], Yuna Miyachi[1], *Arika Tsuji[1], Sae Takami[1], Yuzuki Kobayashi[1] (1.Kyoto Prefectural Sagano High School)

[O03-P42] Summary of our activities and the future direction in the Woods for Field Practice Owned by Sagano High School

*Takeshi Fujimoto[1], Ako Kinoshita[1], Rina Matsuki[1], Yo Sayama[1] (1.Kyoto Prefectural Sagano High School)

[O03-P43] Our challenge, the frozen earth : soil formation under the maple forests in Quebec

Yo Sayama[1], Rina Matsuki[1], Yuzuki Kobayashi[1], *Sae Takami[1], Nahoko Kubo[1] (1.Kyoto Prefectural Sagano High School)

[O03-P44] Color of the moon at the umbra lunar eclipse

*Koudai Fujino[1], *Kotaro Saito[1], *Yoshiki Kujiraoka[1], *Hyate Doi[1], *Ibuki Yasuda[1] (1.Saitama Prefectural Urawa High School)

[O03-P45] Study on vegetation change and validity of eruption age based on pollen analysis of the strata containing volcanic ash

*Taiga Suzuki[1], *Haruki Otiai[1], *Keita Ueno[1], *Athushi Watanabe[1] (1.Nirayama HighSchool)

[O03-P46] Statistical analysis of the columnar joints shape and study of its formation factor using high resolution 3D model by multicopter photos

*Akihito Oota[1], *Kouta Enomoto[1], *Maho Kubota[1], *Minako Nishijima[1], *Atsushi Watanabe[1] (1.Nirayama HighSchool)

[O03-P47] Restoration of the Paleo-Kano Bay

*Souta Kojima[1], *Mao Kubota[1], *Natsuki Yoneyama[1], *Takayuki Yamamoto[1], *Athushi Watanabe[1] (1.Nirayama HighSchool)

[O03-P48] **From deep water circulation to the World's environment**

*Taiga Kokubo[1], *Yuito Tsukada[1], *Hiroki Nakada[1], *Mitsuki Nakada[1], *Hikaru Fujita[1] (1.Zushi-Kaisei Senior High School)

[O03-P49] Mystery of hot and cold Hatoyama

*Yohei Yamamoto[1], *Yusuke Yoshimura[1], *Atsuhide Machida[1], *Syotarou Shinoda[1] (1.Saitama prefectural Kumagaya High School)

[O03-P50] A New Story for Saturn Satellite Dione's History seen in Crater Counting

*Shu Ishibashi[1], *Kyota Kono[1], *Kota Takeda[1] (1.Tennoji Senior High School Attached to Osaka Kyoiku University)

[O03-P51] Which Weather Proverbs are Suitable for The Weather Forecast in Osaka

*Haruto Shimada[1], *Nao Asahi[1], *Aki Yamamoto[1] (1.High School Attached to Osaka Kyoiku University (Tennoji Campus))

[O03-P52] An Effect on Seismic Waves Beneath Active Volcanoes

*Ten Hayashida[1], *Mitsuki Komeda[1], *Miku Yamamoto[1] (1.Tennoji Senior High School Attached to Osaka Kyoiku University)

[O03-P53] The Research Analyzes Structure of Ray with Crater

*Mayuko Suzuki[1], *Mirei Okada[1], Suzuka Kanazawa[1], *Natsuko Okude[1], *Mio Sawai[1], *Meika Minami[1] (1.Tennoji Senior High School Attached to Osaka Kyoiku University)

[O03-P54] The Way of Improving Salt-Damaged Soil

Sezaki Kanon[1], Tamaki Ueno[1], *Ai Kitanishi[1] (1.Tennoji Senior High School Attached to Osaka Kyoiku University)

[O03-P55] Prediction and survey of moonlight power generation amounts –Development of new electricity generation system “Mr. Nisshin Geppo”

*Takaaki Ishimoto[1], *Ryota Suzuki[1], *Koichi Sato[1], *Yuki Yonemura[1], *Hajime Yamamoto[1], *Tatsuya Amamiya[1], *Shinya Amamiya[1] (1.Chuo University Junior and Senior High School)

[O03-P56] Filtering capability of fossil coral skeletons *Porites* sp. and *Favia* sp.

*Yuki Ishisaka[1] (1.Chuo University Senior High School)

[O03-P57] Relationship between the eclipse of partial eclipse and solar radiation and illumination intensity

*Satoshi Yamamoto[1] (1.Hongo senior high school)

[O03-P58] How much can the revolution of the moon be explained by the second law of Kepler?

*Kana Uchida[1], *Haruki Kobata[1], *Toa Hattori[1], Shuhei Asano[1], Mamiko Usui[1] (1.GIZAN SENIOR HIGH SCHOOL)

[O03-P59] The formation age and environment of the Tubo River outcrop,Seki in Gifu prefecture, Central Japan.

*Yuya Yamada[1], *Keisuke Ohno[1] (1.GIZAN SENIOR HIGH SCHOOL)

[O03-P60] The change with time of the gigantic jet off the coast of Ibaraki on December 11, 2017 and comparison with the past jets

*Naoya Yamashita[1], *Shin Hirano[1], *Hayato Matsuyama[1], *Yuya Okubo[1] (1.Shizuoka Prefectural Iwata Minami High School)

[O03-P61] Reconstruction of Late Holocene environmental changes based on analysis ofcore sediments from Kaicho Temple

*Tomoya Ina[1], *Daisuke Suzuki[1], *Keito Tsutahara[1] (1.Shizuoka Prefectural Iwata Minami High School)

[O03-P62] generation of 3D model on the coast of Samejima,the sea of Enshu and detection of coastline by drones

*Eito Takagi[1] (1.Shizuoka Prefectural Iwata Minami High School)

[O03-P63] Factors of beach change on the Ose coast in Ibaraki prefecture

*Kaito Kotsuti[1], *Kosuke Shimano[1], *Haruto Sakachi[1], *Fuyu Tokuda[1], *Syunsuke Nagayama[1], *Hiroki Nemoto[1], *Towa Murakami[1], *Yuki Mimori[1], *Yasushi Wada[1], Takemi Ogawa[1], Eri Yoshida[1] (1.Ibaraki Prefectural Hitachi First Senior High School)

[O03-P64] Hiraodai and Hirotani Wetland Research of soil hardness and water sources + Ramsar Convention

Mariko Hirota[1], *Yujin Ito[1], *Natsuki Abe[1] (1.Higashichikushi Gakuen High school)

[O03-P65] **Ecological study on *Micrasterias hardyi* recently invaded to Lake Biwa: its dependency on water temperature**

*Ayane Kawai[1], Michio Kumagai[2] (1.Shiga Prefectural Ishiyama High School, 2.Authorised NPO Biwako Trust)

[O03-P66] Changing environments on the earth – first termination of overturning in Lake Biwa

*Hinata So[1], Michio Kumagai[2] (1.Shiga Prefectural Zeze High School, 2.Authorized NPO Biwako Trust)

[O03-P67] Let's solve the mystery of gyre drift toward north !

*Masaki Tsuji[1], Michio Kumagai[2] (1.Shiga Prefectural Zeze High School, 2.Authorized NPO Biwako Trust)

[O03-P68] Exploring Atmospheric Properties from Color Change Observation of the International Space Station

Kuroiwa Hiroaki[1], *Ishimura Daiki[1], *Kurohabaki Nanami[1], *Takizawa Shizuku[1], *Yamamoto Yuka[1] (1.Iiyama Senior High School)

[O03-P69] Re-examination of capillary phenomena with gravity as a variable : Second report

*Koushi Hashimoto[1], *Haruka Ono[1], *Riku Nakaima[1], *Takeo Matsuda[1], *Yoshie Sawazaki[1], *Takako Yamashita[1], *Takeru Wakabayashi[1] (1.Otemae Senior High School of Osaka prefecture : the evening course)

[O03-P70] The Study of Kabutoyama

*Manami Nakazawa[1], *Masahiro Okuyama[1], Dai Iijima[1], Haruta Moriya[1], Ayato Watanabe[1] (1.Yamanashi prefectural Hikawa Highschool)

[O03-P71] Proposal of GEO-KAMISHIBAI that enhances the appeal of SANRIKU Geopark and conveys it in an easy-to-understand.

*Keisei Yasuhara[1], *Kana Kato[1], *Mizuho Gondai[1], *Arisa Okubo[1], *Haruto Kawasaki[1], *Mai Kawabata[1], *Seiya Yoshida[1], *Hitomi Kimura[1] (1.Mariento Chikyu Tanken Club Senior)

[O03-P72] Research of the Fukui Earthquake Fault (VII)

*Nobuyasu Nagata[1], *Takuma Yoshizawa[1], Shintaro Umeda[1], Reiji Ohigashi[1], Mahiro Tajima[1], Ryuto Kubota[1] (1.Fujishima High School)

[O03-P73] Estimation of sedimentary environment of volcaniclastic deposit and location of craters in the Nomashi formation, Izu Oshima

*Kouki Aida[1] (1.Musashi High School and Junior High School)

[O03-P74] Why Is the Baseball Ground in Our School Badly Drained ?

*Ryou Ito[1], *Shuta Aoshima[1], *Tomoya Mizutani[1], *Daichi Ishii[1], Yosuke Saito[1] (1.Tokyo Gakugei University Senior High School)

[O03-P75] Spectroscopic observations of Geminids with video cameras and diffraction grating

Yuzaburo Takamura[1], *Momoo Hayashi[1], Moeka Yamagishi[1], Keisuke Nobutoki[1], Yuna Buma[1], Fuyuno Anpuku[1] (1.Ichinomiya High School)

[O03-P76] Observation of the dust storm over the polar cap of Mars

Yuzaburo Takamura[1], *Rino Hayakawa[1], Soma Ohashi[1], Yuna Kuriki[1] (1.Ichinomiya High School)

[O03-P77] Analyzing the shape of (51)Nemausa

*Taiga Hirozawa[1], Suguru Okada[1], Tomoki Suzuki[1], Tomohiro Shibayama[1] (1.Ichinomiya High School)

[O03-P78] Characteristics of lightning discharge that generated sprites

Kazuki KOJIMA[1], Nanami INOUCHI[1], *Misa NAKASUJI[1], *Yasumichi NAKAHAMA[1] (1.Kagawa Prefectural Sambommatsu High School)

[O03-P79] Get closer to the mustery of Sprites and Elves.

*Ayumu Nishihara[1], *Shogo Kawamura[1], *Hidetoshi Oka[1], Daichi Iriki[1], Shunsuke Nakao[1] (1.Prefectural Kochi Ozu High School)

[O03-P80] Prediction of the giant-squid movement around Japan using the dataset of ocean current and temperature.

*Yuka Koike[1] (1.Hiroo Gakuen Senior High School)

[J] Oral | O (Public)：Public

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 106 1F

[O-04] New earth and planetary science education created by hybrid community between society and JpGU

convener:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Chairperson:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki AKIMOTO(Dokkyo University)

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[O04-01] In the next Course of Study, let's send information on world standard "geography / geography" from Japan to the world

★Invited Papers

*YOJI TAKIKAWA[1] (1.NPO Association of Science Curriculum Initiative NPO Galileo Science Workshop)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[O04-02] What a mantle scientist hopes geoscience education

★Invited Papers

*Natsue Abe[1] (1.R&D Center for Ocean Drilling Science Japan Agency for Marine-Earth Science and Technology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[O04-03] New high-school compulsory subject “General Geography” and related cooperation of geographers and earth scientists for human resource development

★Invited Papers

*Takashi Oguchi[1] (1.Center for Spatial Information Science, The University of Tokyo)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[O04-04] Visualization of terrain by Red Relief Image Map(RRIM) and geoscience education

★Invited Papers

*Tatsuro Chiba[1] (1.Asia Air Survey Co., Ltd.)

[J] Oral | O (Public)：Public

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 106 1F

[O-04] New earth and planetary science education created by hybrid community between society and JpGU

convener:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Chairperson:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki AKIMOTO(Dokkyo University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[O04-05] A lesson plan using Tsunami to cultivate the ability to think critically about a subject based on the data given in New government curriculum guidelines for "Basic Earth Science"

★Invited Papers

*Kodama Hidefumi[1] (1.Chiba Prefectural Matudokokusai High School)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[O04-06] The planning of “Integrated Geography” and its aimed competency

★Invited Papers

*Yasutaka Kogawa[1] (1.Okayama Prefectural Tsuyama High School)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[O04-07] Earth and planetary science education considered by the current student

★Invited Papers

*Hideto Otsuka[1] (1.Geology Course, Department of Science, Faculty of Science, Shinshu University, National University Corporation)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[O04-08] Invitation to Geography —Relationship Between Geography and Intellectual Curiosity in Daily Life–

★Invited Papers

*Takuya Miyao[1] (1.Master Program in Education, University of Tsukuba)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[O04-09] Let's build a bridge between "Rika" and society with new geography and geology education in class

★Invited Papers

*Naoki Hosaka[1] (1.science writer)

[J] Oral | O (Public)：Public

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 101 1F

[O-05] English improvement tips for Japanese scientists

convener:Chisato Yoshikawa(Japan Agency for Marine-Earth Science and Technology), Wonsuh Song(Waseda University), Rumi Ohgaito(Japan Agency for Marine-Earth Science and Technology), Chairperson:Chisato Yoshikawa(JAMSTEC), Wonsuh Song, RUMI OGAITO(JAMSTEC)

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[O05-01] Giving a successful presentation in English: Mission Possible!

★Invited Papers

*Joel Laurier[1] (1.University of Tsukuba)

11:05 AM - 11:25 AM JST | 2:05 AM - 2:25 AM UTC

[O05-02] How to deliver good presentations in a foreign language

★Invited Papers

*S. Lan Smith[1] (1.Marine Ecosystem Dynamics Research Group, Research Centre for Global Change, Japan Agency for Marine-Earth Science and Technology)

[J] Poster | O (Public)：Public

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_1

[O-06] How to cope with intensifyng storm and flood disasters

convener:Jun Matsumoto(Deaprtment of Geography, Tokyo Metropolitan University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Akira Wada(Tokyo Institute of Technology)

[O06-P01] Automatic extraction analysis of widespread sediment disasters from satellite images in the Heavy Rain Event of July 2018, Japan

*Hiroyuki Shimomura[1], Kanichiro Mochizuki[1], Tomokazu Itano[1], Atsuo Noda[1], Yasuaki Honda[1], Mayumi Miyazaki[1], Masashi Omata[1], Noriyuki Shibuya[1] (1.PASCO CORPORATION)

[O06-P02] Examination of the factors influencing the people's evacuation behaviors and cognition of reconstruction in the western Japan heavy rain disaster in July 2018

*Shoji Ohtomo[1], Reo Kimura[2] (1.Konan Women's University, 2.University of Hyogo)

[J] Poster | O (Public)：Public

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_1

[O-06] How to cope with intensifyng storm and flood disasters

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[O06-P02] Examination of the factors influencing the people's evacuation behaviors and cognition of reconstruction in the western Japan heavy rain disaster in July 2018

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[J] Oral | O (Public)：Public

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 103 1F

[O-06] How to cope with intensifyng storm and flood disasters

convener:Jun Matsumoto(Deaprtment of Geography, Tokyo Metropolitan University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Akira Wada(Tokyo Institute of Technology), Chairperson:Jun Matsumoto(Tokyo Metropolitan University)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[O06-01] Extreme rainfall and heat wave over Japan in 2018 summer: A series of extreme events and underlying global warming

★Invited Papers

*Hisashi Nakamura[1] (1.Research Center for Advanced Science and Technology, University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[O06-02] Influence of meteorological disasters on marine ecosystem

★Invited Papers

*Yu Umezawa[1,2] (1.Tokyo University of Agriculture and Technology, 2.Study Group on Marine Environmental Problems, the Oceanographic Society of Japan)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[O06-03] Understanding of geomorphic condition indicating the flooding disaster and hazard mapping

★Invited Papers

*Yohta KUMAKI[1] (1.Senshu University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[O06-04] A role of free satellite remote sensing data as a case study of heavy rain disaster in July 2018

★Invited Papers

*Yuji Sakuno[1] (1.Graduate School of Engineering, Hiroshima University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[O06-05] State of the Crisis Mapping for heavy rain in west of Japan, 2018.

★Invited Papers

*Taichi Furuhashi[1] (1.Aoyama Gakuin University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[O06-06] A Study on Spatial and Temporal Resolution of Evacunation Infomation for Effective Evacuation Behavior

★Invited Papers

*Michinori Hatayama[1] (1.Disaster Prevention Research Institute, Kyoto University)

[J] Oral | O (Public)：Public

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 103 1F

[O-06] How to cope with intensifyng storm and flood disasters

convener:Jun Matsumoto(Deaprtment of Geography, Tokyo Metropolitan University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Akira Wada(Tokyo Institute of Technology), Chairperson:Akira Wada(Tokyo Institute of Technology), Yukihiro Takahashi(Hokkaido University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[O06-07] Multi-layered Countermeasures against Widespread Devastating Flood Disasters

★Invited Papers

*Koike Toshio[1] (1.International Centre for Water Hazard and Risk Management)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[O06-08] Technologies and wisdom in housings and buildings for protecting our lives from river floods

★Invited Papers

*Kazuo Tamura[1] (1.Seismic Design Laboratory)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[O06-09] State and Challenges of Disaster Waste Management - Lessons from Recent Disasters –

★Invited Papers

*Yuichi Moriguchi[1], Masahiro Osako[2] (1.Graduate School of Engineering, The University of Tokyo, 2.Center for Material Cycles and Wasre Management Research, National Institute for Environmental Studies)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[O06-10] Evacuation Planning for School Children and Community Residents

★Invited Papers

*Takeshi Sato[1], Yoshiaki Yazaki[2] (1.Tohoku University, 2.Institute of Safety Education for School Children)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[O06-11] Health Emergency and Nursing on Flood Disaster

★Invited Papers

*Sakiko Kanbara[1], Aiko Yamamoto[2] (1.University of Kochi, 2.Shitennoji University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[O06-12] General discussion

*Jun Matsumoto[1,2], Yukihiro Takahashi[3], Akira Wada[4] (1.Tokyo Metropolitan University, 2.JAMSTEC, 3.Hokkaido University, 4.Tokyo Institute of Technology)

[J] Oral | O (Public)：Public

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Convention Hall B 2F

[O-07] Kitchen Earth Science: Let's stimulate your brain by hands-on experiments!

convener:Ichiro Kumagai(School of Science and Engineering, Meisei University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kei Kurita, Mie Ichihara(Earthquake Research Institute, University of Tokyo), Chairperson:Ichiro Kumagai(Meisei University), Miwa Kuri(東北大学災害科学国際研究所), Mie Ichihara(Earthquake Research Institute, The University of Tokyo), Kei Kurita

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[O07-01] Analogue experiments for understanding a crystal morphology variation of igneous rocks using a no-calorie sweetener

*Kuniyuki Furukawa[1], Ririka Watanabe[1], Risa Ito[1], Saori Kotani[1] (1.Faculty of Business Administration, Aichi University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[O07-02] Making volcanic edifice with edible lava

*Tatsuo Kanamaru[1], Akihiko Fujinawa[2] (1.Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University, 2.Department of Earth Sciences, Faculty of Science, Ibaraki University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[O07-03] Columnar joint: Geometric pattern analysis and analogue experiment using starch pastes

*Yuri Akiba[1], Aika Takashima[1], Hiroyuki Shima[2] (1.Graduate School of Life and Environmental Sciences, University of Yamanashi, 2.Department of Environmental Sciences, University of Yamanashi)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[O07-04] Viscoelastic characterization of a solid projectile impact onto a dense potato starch suspension

Kazuya Egawa[2], *Hiroaki Katsuragi[1] (1.Graduate School of Environmental Studies, Nagoya University, 2.Department of Earth and Planetary Sciences, Nagoya University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[O07-05] Pattern formation within a sandpile formed by a mixture of grains: The selection of stratification and segregation patterns

★Invited Papers

*Michiko Shimokawa[1], Hidestugu Sakaguchi[2] (1.Fukuoka Institute of Technology, 2.Kyushu University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[O07-06] Measuring radiation by DIY Geiger Counter Kit GC10

*George HASHIMOTO[1], Yusuke KOSHIO[1] (1.Department of Earth Sciences, Okayama University)

[J] Poster | O (Public)：Public

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_1

[O-07] Kitchen Earth Science: Let's stimulate your brain by hands-on experiments!

convener:Ichiro Kumagai(School of Science and Engineering, Meisei University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kei Kurita, Mie Ichihara(Earthquake Research Institute, University of Tokyo)

[O07-P01] Application of kitchen earth science for multidisciplinary and interdisciplinary education

*Miwa Kuri[1] (1.International Research Institute of Disaster Science, Tohoku University)

[O07-P02] Considering controlling factors of eruption styles through syrup eruption experiments

*Mie Ichihara[1], Kazuya Yamakawa[1], Kurumi Iwahashi[1], Akira Nishijo[1], Yo Kanno[1] (1.Earthquake Research Institute, University of Tokyo)

[O07-P03] Cooking karinto, analogical link to magmatic vesiculation and explosion

*Kei Kurita[1], Ichiro Kumagai[3], Mie Ichihara[1], Ayumi Ogawa[2], Michiyo Kumagai[2], yusaku nagata[2], Midori Kasai[2] (1.The University of Tokyo, 2.Ochanomizu University, 3.Meisei University)

[J] Poster | O (Public)：Public

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_2

[O-07] Kitchen Earth Science: Let's stimulate your brain by hands-on experiments!

convener:Ichiro Kumagai(School of Science and Engineering, Meisei University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kei Kurita, Mie Ichihara(Earthquake Research Institute, University of Tokyo)

[O07-P01] Application of kitchen earth science for multidisciplinary and interdisciplinary education

*Miwa Kuri[1] (1.International Research Institute of Disaster Science, Tohoku University)

[O07-P02] Considering controlling factors of eruption styles through syrup eruption experiments

*Mie Ichihara[1], Kazuya Yamakawa[1], Kurumi Iwahashi[1], Akira Nishijo[1], Yo Kanno[1] (1.Earthquake Research Institute, University of Tokyo)

[O07-P03] Cooking karinto, analogical link to magmatic vesiculation and explosion

*Kei Kurita[1], Ichiro Kumagai[3], Mie Ichihara[1], Ayumi Ogawa[2], Michiyo Kumagai[2], yusaku nagata[2], Midori Kasai[2] (1.The University of Tokyo, 2.Ochanomizu University, 3.Meisei University)

[J] Oral | O (Public)：Public

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Convention Hall B 2F

[O-08] How to make the image of the earth's phenomenon to the general people in the Geopark

convener:Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Yayoi ICHIHASHI(Sado Island Geopark Promotion Office), Hokuto Obara(Mine-Akiyoshidai Karst Plateau Geopark Promotion Council), Marekazu OHNO(Unzen Volcanic Area Geopark Promotion Office), Chairperson:Yayoi Ichihashi, Hokuto Obara, Hiroko Imai, Suzuka Koriyama(San'in Kaigan Geopark Promotion Council), Noritaka Matsubara(兵庫県立大学大学院)

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[O08-01] Significance of the guide to introduce the landscape interestingly

★Invited Papers

*Daisuke Fukushima[1] (1.Sakurajima Museum)

11:15 AM - 11:45 AM JST | 2:15 AM - 2:45 AM UTC

[O08-02] Understanding of "geology" without difficult explanation. - Let's conduct experiment to tell about geology more easily. -

★Invited Papers

*Hikaru Yokoyama[1] (1.Hokusho University)

11:45 AM - 12:15 PM JST | 2:45 AM - 3:15 AM UTC

[O08-03] The appealing points and challenges of Japanese geoparks, as seen from a foreigner’s point of view.

★Invited Papers

*Jagoda Woloszyn[1] (1.Oki Islands UNESCO Global Geopark Promotion Committee)

[J] Oral | O (Public)：Public

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Convention Hall B 2F

[O-08] How to make the image of the earth's phenomenon to the general people in the Geopark

convener:Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Yayoi ICHIHASHI(Sado Island Geopark Promotion Office), Hokuto Obara(Mine-Akiyoshidai Karst Plateau Geopark Promotion Council), Marekazu OHNO(Unzen Volcanic Area Geopark Promotion Office), Chairperson:Yayoi Ichihashi, Hokuto Obara, Hiroko Imai, Noritaka Matsubara(兵庫県立大学大学院), Suzuka Koriyama(San'in Kaigan Geopark Promotion Council)

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[O08-04] What do we need to do fun geotours that interests the earth?

★Invited Papers

*kana nishitani[1] (1.Global nature club)

2:15 PM - 2:45 PM JST | 5:15 AM - 5:45 AM UTC

[O08-05] The Important Things in Communicating Earth's Activity to Local Residents: the Awareness during Four Years after Changing a Job from a Geoscience Postdoc to a Curator

★Invited Papers

*Kyoko Kanayama[1] (1.San'in Kaigan Geopark Museum of the Earth and Sea, Tottori Prefectural Government)

2:45 PM - 3:15 PM JST | 5:45 AM - 6:15 AM UTC

[O08-06] "Blatamori" How to communicate the earth activities valued by guide guides

★Invited Papers

*Makoto Hasuoka[1], Yusuke Suzuki[2], Hiroko Imai[3] (1.Bandai-san Geopark Council, 2.Izu Peninsula Geopark Promotion Council, 3.COM SUPPORT OFFICE)

[J] Poster | O (Public)：Public

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_2

[O-08] How to make the image of the earth's phenomenon to the general people in the Geopark

convener:Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Yayoi ICHIHASHI(Sado Island Geopark Promotion Office), Hokuto Obara(Mine-Akiyoshidai Karst Plateau Geopark Promotion Council), Marekazu OHNO(Unzen Volcanic Area Geopark Promotion Office)

[O08-P01] An analysis of the implementation of Mikasa Geopark`s experienced-based GeoTour and its impacts on recruitment and changes in the participant population.

*kei SHIMOMURA[1,2], souta KAMIGUCHI[1,2] (1.Mikasa Geopark Promotion council, 2.Regional Development and Geopark Promotion Division, Mikasa City Office)

[O08-P02] Strategy for revaluation and promotion of Toya-Usu UNESCO Global Geopark through SDGs

*Nire Kagaya[1] (1.Toya-Usu UNESCO Global Geopark Council)

[O08-P03] Examination of the way to convey geo diversity of Mt. Apoi Geopark - Through efforts of geo tour outside the geopark area -

*KATO SATOMI[1] (1.samani town office)

[O08-P04] Geosite Cleanup Activities Leading to Solutions for Global Environmental Problems

*Satoshi Ishikawa[1], Takuya Koike[1] (1.Shimokita geopark promotion council)

[O08-P05] Inspiring geosites and not-inspiring geosites: Case study of the Oga Peninsula-Ogata Geopark

*Norihito Kawamura[1] (1.Faculty of Education and Human Studies, Akita University)

[O08-P06] Are habitats such as fumaroles or areas with heavy snowfall suitable for organisms living in Yuzawa Geopark?
Considering the efficacy of the Geopark Guides with a focus on Yamatanukiran and snow camellia.

*Haruki Takayanagi[1] (1.Yuzawa Geopark Promotion Council)

[O08-P07] **The evaluation of geosites in Sanriku Geopark**

*Sho Nagata[1], Hideo Takagi[2] (1.Waseda University, 2.Department of Earth Science, Faculty of Education and Integrated Arts and Sciences, Waseda University)

[O08-P08] **The nature experience program created by Geopark and National Youth Outdoor Learning Center**

*Takuya Harada[1], Mizuki Kobayashi[1], Ken-ichi Yamada[2], Akiyoshi Adachi[2] (1.Mt. Kurikoma Area Geopark Promotion Committee, 2.National Hanayama Youth Outdoor Learning Center)

[O08-P09] A review of geosites in the Bandaisan Geopark

*Yojiro Taketani[1], Hiroshi Sato[2], Makoto Hasuoka[1] (1.Bandaisan Geopark Council, 2.Mt. Bandai Museum)

[O08-P10] Receiving a Yellow Card: Efforts and Future Actions of Sado Island Geopark

*Yayoi ICHIHASHI[1] (1.Sado Islanad Geopark Promotion Office)

[O08-P11] Method for resetting geosites and their use in Sado Island Geopark

*Takeyoshi SADAKANE[1], Yayoi ICHIHASHI[1], Mituhisa AIDA[1] (1.Sado Island Geopark Promotion Office)

[O08-P12] Look back on the 10 years at the statistical data of the Itoigawa UNESCO Global Geopark

*Takahiko Ogawara[1], Ko Takenouchi[1], Yousuke Ibaraki[1], Takeo Kobayashi[2] (1.Fossa Magna Museum, 2.Itoigawa Geopark Promotion Office)

[O08-P13] Application of terrain representation in Geosite
- Case study in North Ibaraki Geopark Project -

*Go Ishikawa[1], Keiko SUZUKI[1], Mamoru Koarai[2], Rika Imaizumi[3], Naoki Takeda[4] (1.Tokyo Map Research Inc., 2.College of Science, Ibaraki University, 3.Aero Asahi Corp., 4.Association for Promotion of North Ibaraki Geopark Project)

[O08-P14] Evaluation and utilization of 34 geosites in Geopark Chichibu

*Hideo Takagi[1], Satomi Hirose[2] (1.Department of Earth Science, Faculty of Education and Integrated Arts and Sciences, Waseda University, 2.School of Education, Waseda University)

[O08-P16] Aiming for Further Development in Hakone Geopark

Ichiro Murayama[1], Shinobu Katano[1], *Yusuke Okutsu[1] (1.Hakone Geopark Promotion Council)

[O08-P17] Citizen Science Forecast and Evaluate Ship and Airplane Operation Success to a Remote Oceanic Island: a case study for Izu-oshima

Kazuhiro Nakamura[2], Juri Hashimoto[1], *Rika Usui[1], Yuichiro Teramoto[1], Kana Nishitani[3] (1.Izu Oshima Geopark Promotion Committee, 2.Former Tokyo Metropolitan Oshima High School Teacher, 3.Corp. Global Sport Club)

[O08-P18] Minami-Alps Geopark Development of programs for education and spread activities

*Eri Ozawa[1], Takahiro Kitahara[1], Airi Karasawa[1] (1.Minami-Alps MTL area Geopark Council)

[O08-P19] Present situation and issues of the Tateyama Kurobe Geoparkafter Yellow card

*Yuta Yamaoka[1], Akira Takeuchi[1], Hajime Iida[2], Kiyoshi Imai[1], Kazuo Kaneko[1], Yukimitsu Shimura[1], Osamu Inamura[3], Tohru Ikurumi[4], Kiichi Imahori[1], Satoshi Kotani[1] (1.Tateyama Kurobe Geopark Society, 2.Tateyama Caldera Sabo Museum, 3.Uozu Aquarium, 4.Lifelong Learning Division, The Board of Education, Kurobe City)

[O08-P20] 1 year survey conducted by Hakusan Tedorigawa Geopark regarding number of pamphlets taken from Roadside station Shirayamasan

*Nakano Kaori[1], Tsuyoshi Hibino[1], Ryoichi Onishi[1] (1.Hakusan Tedorigawa Geopark Promotion Council)

[O08-P21] Promotion of the earth science utilizing the Geopark “Making the stone specimen in Hakusan Tedorigawa Japanese Geopark”

*Yuya Kitoh[1], Satoshi Hirai[1], Kiyofumi Tamamura[1], Tsuyoshi Hibino[2], Kaori Nakano[2], Tomoaki Morishita[3], Yoshihiro Hiramatsu[3], Maki Hamada[3] (1.Ishikawa Geological Survey Association, 2.Hakusan Tedorigawa Geopark Promotion Council, 3.Kanazawa University)

[O08-P22] School Trip from Hong Kong to Dinosaur Valley Fukui Katsuyama Geopark : Challenges and Prospects

*Sumiaki Machi[1] (1.Dinosaur Valley Fukui Katsuyama Geopark Promotion Council)

[O08-P23] Outline of the activities of the Kumano Kodo Ohechi Rangers

*Keishi Jimbo[1] (1.Nanki Kumano Geopark Guide Club)

[O08-P24] Diversity of Nature Activities Related Geodiversity

maeda atsushi[2], Ministry of the Environment Kinki Regional Environment Office, *Suzuka Koriyama[1], Noritaka Matsubara[3] (1.Sanin Kaigan Geopark Promotion Council, 2.SGAR, 3.Graduate School of Regional Resource Management, University of Hyogo)

[O08-P25] Understanding of regional scientific importance by local Residents – In case of San’in Kaigan UNESCO Global Geopark

*Noritaka Matsubara[1] (1.Graduate School of Regional Resource Management, University of Hyogo)

[O08-P26] Stones forming tombs of feudal lords during Edo period in some geoparks located along the coast of the Sea of Japan

*Tohru Sakiyama[1] (1.Graduate School of Regional Resource Management, University of Hyogo)

[O08-P27] Science Design to make the earth attractive

*Miho Sasaoka[1], Mine-Akiyoshidai Geopark[2] (1.Kochi University / SASAMI-GEO-SCIENCE, Inc., 2.Mine-Akiyoshidai Karst Plateau Geopark)

[O08-P28] ‘Be one with the earth; help each other’: the Geopark activities of Mine-Akiyoshidai Karst Plateau Geopark

*Hokuto Obara[1], Tomoko Muratani[1], Tristan Gray[1], Kazuhiro Yuhora[2], Koji Wakita[3] (1.Mine-Akiyoshidai Karst Plateau Geopark Promotion Council, 2.Tottori University of Environmental Studies, 3.Yamaguchi University)

[O08-P29] Highlights of Suzaki Coast, Shikoku Seiyo Geopark - Kurosegawa Tectonic Zone, geologic strata of 400 million years ago -

*Chisato Nakamura[1], Tomohiro Tsuji[2], Shikoku Seiyo Geopark Promotion Council [3] (1.NAIBA Co. Ltd., 2.Shikoku Research Institute INC., 3.Seiyo City)

[O08-P30] The Efforts of the Shikoku Seiyo Geopark after the revalidation from JGN council and the 2018 Japan Floods.

*Takumi Sakakiyama[1], Fumito Doi[1], Koshiro Utsunomiya[1], Tsukasa Takahashi[1] (1.Shikoku Seiyo Geopark Promotion Council)

[O08-P31] Method of enjoying relationships with the earth and culture in "the central Shikoku island".

*Azusa Tonotani[1,2], Kana Nakao[1,2], Kazuyoshi Ishii[2], Takuma Asa[3], Soichiro Sagawa[3], Kenshi Nishinari[3], Iori Yamamoto[3], Hisashi Hirao[3], Keiji Nakagawa[3] (1.Miyoshi city office, 2.Geoguides of Miyoshi city, 3.Tokushima prefectural Ikeda high school)

[O08-P32] Bridge of scientific research to school education in a geopark, using a research fund of Muroto UNESCO Geopark

*Takeyuki Ueki[1] (1.Faculty of Risk and Crisis Management, Chiba Institute of Science)

[O08-P33] New basic philosophy of Unzen Volcanic Area UNESCO Global Geopark made in union with local residents and government officers.

*Taku MORIMOTO[1], Marekazu OHNO[1] (1.Unzen Volcanic Area Geopark Promotion Office)

[O08-P34] Evaluation of explanation panels settling at geopark's sites – case study of the explanation panel at a memorial park of houses destroyed by debris flows in Unzen Volcanic Area UNESCO Global Geopark, Japan

Sean OTA[1], Shion MORIKITA[1], Kuumu ONIDUKA[1], Tatsuya MORITA[1], Kenshin OSHIMA[1], Yui KURITA[1], Miyu KAWAZOE[1], Toshiki HIGASHIUCHI[2], Hiroaki OSAKO[2], *Marekazu OHNO[3] (1.Glocal Course, Nagasaki Prefecture Koka High School, 2.Nagasaki Prefecture Koka High School, 3.Unzen Volcanic Area Geopark Promotion Office)

[O08-P35] ESD-SDGs Promotion Model Development utilizing Geoparks including the basic research on the contents of educational programs in Geoparks in Japan

Katsuhiko Asahi[1], Yayoi Ichihasi[1], Takahiko Ogawara[1], Shinobu Katano[1], Ken'ichi Kurihara[1], *Suzuka Koriyama[1], Takeo Kobayashi[1], kei Shimomura[1], Yusuke Suzuki[1], Ko Takenouchi[1], Tsuyoshi Hibino[1], Jun Fujishima[1], Kana Furusawa[1], Yu Horiuchi[1], Emiko Mizuno[1], Ko Miyama[1], Yuta Yamaoka[1], Tamami Yamaguchi[1], Yukiko Yamasaki[1], Ryuta Yamamoto[1], Hikaru Yokoyama[1] (1.Japanese Geoparks Network)

[J] Poster | O (Public) : Public

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_3

[O-08] How to make the image of the earth's phenomenon to the general people in the Geopark

convener:Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Yayoi ICHIHASHI(Sado Island Geopark Promotion Office), Hokuto Obara(Mine-Akiyoshidai Karst Plateau Geopark Promotion Council), Marekazu OHNO(Unzen Volcanic Area Geopark Promotion Office)

[O08-P01] An analysis of the implementation of Mikasa Geopark`s experienced-based GeoTour and its impacts on recruitment and changes in the participant population.

*kei SHIMOMURA[1,2], souta KAMIGUCHI[1,2] (1.Mikasa Geopark Promotion council, 2.Regional Development and Geopark Promotion Division, Mikasa City Office)

[O08-P02] Strategy for revaluation and promotion of Toya-Usu UNESCO Global Geopark through SDGs

*Nire Kagaya[1] (1.Toya-Usu UNESCO Global Geopark Council)

[O08-P03] Examination of the way to convey geo diversity of Mt. Apoi Geopark - Through efforts of geo tour outside the geopark area -

*KATO SATOMI[1] (1.samani town office)

[O08-P04] Geosite Cleanup Activities Leading to Solutions for Global Environmental Problems

*Satoshi Ishikawa[1], Takuya Koike[1] (1.Shimokita geopark promotion council)

[O08-P05] Inspiring geosites and not-inspiring geosites: Case study of the Oga Peninsula-Ogata Geopark

*Norihito Kawamura[1] (1.Faculty of Education and Human Studies, Akita University)

[O08-P06] Are habitats such as fumaroles or areas with heavy snowfall suitable for organisms living in Yuzawa Geopark?
Considering the efficacy of the Geopark Guides with a focus on Yamatanukiran and snow camellia.

*Haruki Takayanagi[1] (1.Yuzawa Geopark Promotion Council)

[O08-P07] **The evaluation of geosites in Sanriku Geopark**

*Sho Nagata[1], Hideo Takagi[2] (1.Waseda University, 2.Department of Earth Science, Faculty of Education and Integrated Arts and Sciences, Waseda University)

[O08-P08] **The nature experience program created by Geopark and National Youth Outdoor Learning Center**

*Takuya Harada[1], Mizuki Kobayashi[1], Ken-ichi Yamada[2], Akiyoshi Adachi[2] (1.Mt. Kurikoma Area Geopark Promotion Committee, 2.National Hanayama Youth Outdoor Learning Center)

[O08-P09] A review of geosites in the Bandaisan Geopark

*Yojiro Taketani[1], Hiroshi Sato[2], Makoto Hasuoka[1] (1.Bandaisan Geopark Council, 2.Mt. Bandai Museum)

[O08-P10] Receiving a Yellow Card: Efforts and Future Actions of Sado Island Geopark

*Yayoi ICHIHASHI[1] (1.Sado Islanad Geopark Promotion Office)

[O08-P11] Method for resetting geosites and their use in Sado Island Geopark

*Takeyoshi SADAKANE[1], Yayoi ICHIHASHI[1], Mituhisa AIDA[1] (1.Sado Island Geopark Promotion Office)

[O08-P12] Look back on the 10 years at the statistical data of the Itoigawa UNESCO Global Geopark

*Takahiko Ogawara[1], Ko Takenouchi[1], Yousuke Ibaraki[1], Takeo Kobayashi[2] (1.Fossa Magna Museum, 2.Itoigawa Geopark Promotion Office)

[O08-P13] Application of terrain representation in Geosite
- Case study in North Ibaraki Geopark Project -

*Go Ishikawa[1], Keiko SUZUKI[1], Mamoru Koarai[2], Rika Imaizumi[3], Naoki Takeda[4] (1.Tokyo Map Research Inc., 2.College of Science, Ibaraki University, 3.Aero Asahi Corp., 4.Association for Promotion of North Ibaraki Geopark Project)

[O08-P14] Evaluation and utilization of 34 geosites in Geopark Chichibu

*Hideo Takagi[1], Satomi Hirose[2] (1.Department of Earth Science, Faculty of Education and Integrated Arts and Sciences, Waseda University, 2.School of Education, Waseda University)

[O08-P16] Aiming for Further Development in Hakone Geopark

Ichiro Murayama[1], Shinobu Katano[1], *Yusuke Okutsu[1] (1.Hakone Geopark Promotion Council)

[O08-P17] Citizen Science Forecast and Evaluate Ship and Airplane Operation Success to a Remote Oceanic Island: a case study for Izu-oshima

Kazuhiro Nakamura[2], Juri Hashimoto[1], *Rika Usui[1], Yuichiro Teramoto[1], Kana Nishitani[3] (1.Izu Oshima Geopark Promotion Committee, 2.Former Tokyo Metropolitan Oshima High School Teacher, 3.Corp. Global Sport Club)

[O08-P18] Minami-Alps Geopark Development of programs for education and spread activities

*Eri Ozawa[1], Takahiro Kitahara[1], Airi Karasawa[1] (1.Minami-Alps MTL area Geopark Council)

[O08-P19] Present situation and issues of the Tateyama Kurobe Geoparkafter Yellow card

*Yuta Yamaoka[1], Akira Takeuchi[1], Hajime Iida[2], Kiyoshi Imai[1], Kazuo Kaneko[1], Yukimitsu Shimura[1], Osamu Inamura[3], Tohru Ikurumi[4], Kiichi Imahori[1], Satoshi Kotani[1] (1.Tateyama Kurobe Geopark Society, 2.Tateyama Caldera Sabo Museum, 3.Uozu Aquarium, 4.Lifelong Learning Division, The Board of Education, Kurobe City)

[O08-P20] 1 year survey conducted by Hakusan Tedorigawa Geopark regarding number of pamphlets taken from Roadside station Shirayamasan

*Nakano Kaori[1], Tsuyoshi Hibino[1], Ryoichi Onishi[1] (1.Hakusan Tedorigawa Geopark Promotion Council)

[O08-P21] Promotion of the earth science utilizing the Geopark “Making the stone specimen in Hakusan Tedorigawa Japanese Geopark”

*Yuya Kitoh[1], Satoshi Hirai[1], Kiyofumi Tamamura[1], Tsuyoshi Hibino[2], Kaori Nakano[2], Tomoaki Morishita[3], Yoshihiro Hiramatsu[3], Maki Hamada[3] (1.Ishikawa Geological Survey Association, 2.Hakusan Tedorigawa Geopark Promotion Council, 3.Kanazawa University)

[O08-P22] School Trip from Hong Kong to Dinosaur Valley Fukui Katsuyama Geopark : Challenges and Prospects

*Sumiaki Machi[1] (1.Dinosaur Valley Fukui Katsuyama Geopark Promotion Council)

[O08-P23] Outline of the activities of the Kumano Kodo Ohechi Rangers

*Keishi Jimbo[1] (1.Nanki Kumano Geopark Guide Club)

[O08-P24] Diversity of Nature Activities Related Geodiversity

maeda atsushi[2], Ministry of the Environment Kinki Regional Environment Office, *Suzuka Koriyama[1], Noritaka Matsubara[3] (1.Sanin Kaigan Geopark Promotion Council, 2.SGAR, 3.Graduate School of Regional Resource Management, University of Hyogo)

[O08-P25] Understanding of regional scientific importance by local Residents – In case of San’in Kaigan UNESCO Global Geopark

*Noritaka Matsubara[1] (1.Graduate School of Regional Resource Management, University of Hyogo)

[O08-P26] Stones forming tombs of feudal lords during Edo period in some geoparks located along the coast of the Sea of Japan

*Tohru Sakiyama[1] (1.Graduate School of Regional Resource Management, University of Hyogo)

[O08-P27] Science Design to make the earth attractive

*Miho Sasaoka[1], Mine-Akiyoshidai Geopark[2] (1.Kochi University / SASAMI-GEO-SCIENCE, Inc., 2.Mine-Akiyoshidai Karst Plateau Geopark)

[O08-P28] ‘Be one with the earth; help each other’: the Geopark activities of Mine-Akiyoshidai Karst Plateau Geopark

*Hokuto Obara[1], Tomoko Muratani[1], Tristan Gray[1], Kazuhiro Yuhora[2], Koji Wakita[3] (1.Mine-Akiyoshidai Karst Plateau Geopark Promotion Council, 2.Tottori University of Environmental Studies, 3.Yamaguchi University)

[O08-P29] Highlights of Suzaki Coast, Shikoku Seiyo Geopark - Kurosegawa Tectonic Zone, geologic strata of 400 million years ago -

*Chisato Nakamura[1], Tomohiro Tsuji[2], Shikoku Seiyo Geopark Promotion Council [3] (1.NAIBA Co. Ltd., 2.Shikoku Research Institute INC., 3.Seiyo City)

[O08-P30] The Efforts of the Shikoku Seiyo Geopark after the revalidation from JGN council and the 2018 Japan Floods.

*Takumi Sakakiyama[1], Fumito Doi[1], Koshiro Utsunomiya[1], Tsukasa Takahashi[1] (1.Shikoku Seiyo Geopark Promotion Council)

[O08-P31] Method of enjoying relationships with the earth and culture in "the central Shikoku island".

*Azusa Tonotani[1,2], Kana Nakao[1,2], Kazuyoshi Ishii[2], Takuma Asa[3], Soichiro Sagawa[3], Kenshi Nishinari[3], Iori Yamamoto[3], Hisashi Hirao[3], Keiji Nakagawa[3] (1.Miyoshi city office, 2.Geoguides of Miyoshi city, 3.Tokushima prefectural Ikeda high school)

[O08-P32] Bridge of scientific research to school education in a geopark, using a research fund of Muroto UNESCO Geopark

*Takeyuki Ueki[1] (1.Faculty of Risk and Crisis Management, Chiba Institute of Science)

[O08-P33] New basic philosophy of Unzen Volcanic Area UNESCO Global Geopark made in union with local residents and government officers.

*Taku MORIMOTO[1], Marekazu OHNO[1] (1.Unzen Volcanic Area Geopark Promotion Office)

[O08-P34] Evaluation of explanation panels settling at geopark's sites – case study of the explanation panel at a memorial park of houses destroyed by debris flows in Unzen Volcanic Area UNESCO Global Geopark, Japan

Sean OTA[1], Shion MORIKITA[1], Kuumu ONIDUKA[1], Tatsuya MORITA[1], Kenshin OSHIMA[1], Yui KURITA[1], Miyu KAWAZOE[1], Toshiki HIGASHIUCHI[2], Hiroaki OSAKO[2], *Marekazu OHNO[3] (1.Glocal Course, Nagasaki Prefecture Koka High School, 2.Nagasaki Prefecture Koka High School, 3.Unzen Volcanic Area Geopark Promotion Office)

[O08-P35] ESD-SDGs Promotion Model Development utilizing Geoparks including the basic research on the contents of educational programs in Geoparks in Japan

Katsuhiko Asahi[1], Yayoi Ichihasi[1], Takahiko Ogawara[1], Shinobu Katano[1], Ken'ichi Kurihara[1], *Suzuka Koriyama[1], Takeo Kobayashi[1], kei Shimomura[1], Yusuke Suzuki[1], Ko Takenouchi[1], Tsuyoshi Hibino[1], Jun Fujishima[1], Kana Furusawa[1], Yu Horiuchi[1], Emiko Mizuno[1], Ko Miyama[1], Yuta Yamaoka[1], Tamami Yamaguchi[1], Yukiko Yamasaki[1], Ryuta Yamamoto[1], Hikaru Yokoyama[1] (1.Japanese Geoparks Network)

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[P-PS04] Mars and Mars system: results from a broad spectrum of Mars studies and aspects for future missions

convener:Hideaki Miyamoto(University of Tokyo), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Ayako Matsuoka(Research Division for Space Plasma, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Sushil K Atreya(University of Michigan Ann Arbor), Chairperson:Sushil Atreya

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PPS04-01] Recent results from the MAVEN mission

*Dave A Brain[1,4], Bruce Jakosky[1], Janet Luhmann[2], Gina DiBraccio[3] (1.University of Colorado, 2.University of California Berkeley, 3.NASA Goddard Space Flight Center, 4.University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PPS04-02] From Clouds to Aurora to Atmospheric Escape: Highlights from MAVEN's Imaging UltraViolet Spectrograph

★Invited Papers

*Nicholas McCord Schneider[1], MAVEN/IUVS Science Team (1.LASP, University of Colorado Boulder)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PPS04-03] Variation in Martian Crustal Magnetic Field Cusp Topology

*Tristan David Weber[1], David Brain[1], Shaosui Xu[2], David Mitchell[2], Jasper Halekas[3] (1.University of Colorado, Boulder, 2.Space Sciences Laboratory, UC Berkeley, 3.University of Iowa, Iowa City)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PPS04-04] The Induced Global Looping Magnetic Field on Mars

*Lihui Chai[1], Weixing Wan[1], Yong Wei[1], Tielong Zhang[2], Willi Exner[3], Markus Fraenz[4], Eduard Dubinin[4], Moritz Feyerabend[3], Uwe Motschmann[3], Yingjuan Ma[5], J. S. Halekas[6] (1.Institute of Geology and Geophysics Chinese Academy of Sciences, 2.Space Research Institute, Austrian Academy of Sciences, Graz, Austria, 3.Institute for Theoretical Physics, TU Braunschweig, Braunschweig, Germany, 4.Max Planck Institute for Solar System Research, Goettingen, Germany, 5.Institute of Geophysics and Planetary Physics, University of California, Los Angeles, Los Angeles, CA, USA, 6.Department of Physics and Astronomy, University of Iowa, Iowa City, IA, USA)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PPS04-05] First Observation of Magnetic Pulsations on Martian Surface

*Peter J Chi[1], Christopher T Russell[1], Steve Joy[1], Don Banfield[2], Catherine L Johnson[3,4], Yingjuan Ma[1], Anna Mittelholz[3], Yanan Yu[1] (1.University of California Los Angeles, 2.Cornell University, 3.University of British Columbia, 4.Planetary Science Institute)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PPS04-06] Retrieval of vertical aerosol and gas profiles considering multiple scattering from Martian limb observations by MRO/CRISM

*Yasumasa Kasaba[1], Masashi Toyooka[2], Shohei Aoki[3], Arnaud Mahieux[3,4], Hiromu Nakagawa[2], Hironobu Iwabuchi[2] (1.Planetary Plasma and Atmospheric Research Center (PPARC), Tohoku University, 2.Dep. Geophysics, Tohoku University, 3.Planetary Aeronomy, Belgian Institute for Space Aeronomy, Belgium , 4.University of Texas at Austin, USA)

[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[P-PS04] Mars and Mars system: results from a broad spectrum of Mars studies and aspects for future missions

convener:Hideaki Miyamoto(University of Tokyo), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Ayako Matsuoka(Research Division for Space Plasma, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Sushil K Atreya(University of Michigan Ann Arbor), Chairperson:Hideaki Miyamoto, Tomohiro Usui

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PPS04-07] **MODELING MORE COMPLEX EARLY MARTIAN ATMOSPHERES AND DETERMINING THE RESULTING PRECIPITATION AND EROSION RATES**

*Ramses M Ramirez[1,2] (1.Earth-life Science Institute, 2.Tokyo Institute of Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PPS04-08] GCM simulations of the present and past water environment on Mars

*Takeshi Kuroda[1,2], Arihiro Kamada[1], Katsushige Toriumi[1], Yasumasa Kasaba[1], Naoki Terada[1], Hiromu Nakagawa[1] (1.Faculty of Science, Tohoku University, 2.National Institute of Information and Communications Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PPS04-09] Cold-based glaciation at Pavonis Mons, Mars: Evidence for moraine deposition during glacial advance

★Invited Papers

*Reid Parsons[1,2], Tomohiro Kanzaki[3], Ryodo Hemmi[1], Hideaki Miyamoto[3] (1.University Museum, University of Tokyo, 2.Earth and Geographic Science Dept., Fitchburg State University, 3.Dept. of Systems Innovation, University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PPS04-10] Possible Earth-like tectonic scenario on Mars; a mineralogical and geochemical perspective

*Trishit Ruj[1], Gene W Schimdt[2], Goro Komatsu[2], Kenji Kawai[1] (1.Department of Earth and Planetary Science, School of Science, UTokyo, Japan, 2.International Research School of Planetary Sciences, Università d'Annunzio, Italy)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PPS04-11] Hydration state of the Martian lithosphere constrained from gravity and topography

*James Daniel Paul Moore[1], Jon Wade[2], Anthony B Watts[2], Richard M Palin[3], Lars M Hansen[2], Brendan Dyck[4], Jun Muto[6], Andrew J Smye[5], Adam D Switzer[1] (1.Earth Observatory of Singapore, 2.University of Oxford, 3.Colorado School of Mines, 4.Simon Fraser University, 5.Penn State, 6.Tohoku University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PPS04-12] SUBGLACIAL ANTARCTIC LAKE VOSTOK VS. SUBGLACIAL SOUTH POLE MARTIAN LAKE AND HYPERSALINE CANADIAN ARCTIC LAKES – PROSPECTS FOR LIFE

*Sergey Bulat[1] (1.NRC KI - Petersburg Nuclear Physics Institute, Saint-Petersburg-Gatchina, Russia)

[E] Poster | P (Space and Planetary Sciences)：P-PS Planetary Sciences

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_3

[P-PS04] Mars and Mars system: results from a broad spectrum of Mars studies and aspects for future missions

convener:Hideaki Miyamoto(University of Tokyo), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Ayako Matsuoka(Research Division for Space Plasma, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Sushil K Atreya(University of Michigan Ann Arbor)

[PPS04-P01] Observation of the O_2^+ first negative band (1,0) emissions in the Mars ionosphere with a visible spectrograph on Haleakala T60

*Toshihisa Suzuki[1], Masato Kagitani[1], Takeshi Sakanoi[1] (1.PPARC, Graduate School of Science, Tohoku University)

[PPS04-P02] Search of shallow subsurface reflectors around RSLs in Martian Chryse and Acidalia planitiae by the MRO/SHARAD public data

*Aina Oura[1], Yasumasa Kasaba[1], Atsushi Kumamoto[1], Rina Noguchi[2], Tomohiro Usui[2], Ken Ishiyama[2], Chihiro Uemura[3] (1.Tohoku University, 2.Institute of Space and Astronautical Science, 3.SOKENDAI)

[PPS04-P03] Detecting surface changes on Mars using principle component analysis of repeat imagery

*Reid Parsons[1], Hideaki Miyamoto[1] (1.University of Tokyo)

[PPS04-P04] Evaluation of the detectability of hydrated salts on recurring slope lineae on Mars.

*Shoko Imamura[1,2], Yasuhito Sekine[2], Hiroyuki Kurokawa[2] (1.University of Tokyo, 2.Earth-Life Science Institute, Tokyo Institute of Technology)

[PPS04-P05] Frequency of ice sheet growth recorded on Mons Pavonis, Mars

*Tomohiro Kanzaki[1], Reid Parsons[1,2], Ryodo Hemmi[1], Hideaki Miyamoto[1] (1.University of Tokyo, 2.Fitchburg State University)

[PPS04-P06] Development of Life Detection Microscope (LDM) for *in situ* imaging of living cells on Mars surface

*Yoshitaka Yoshimura[1], Akihiko Yamagishi[2], Takehiko Satoh[3], Atsuo Miyakawa[2], Eiichi Imai[4], Satoshi Sasaki[5], Kensei Kobayashi[6], Yoko Kebukawa[6], Tomoka Okada[6], Keigo Enya[3], Hikaru Yabuta[7], Takeshi Naganuma[7], Hajime Mita[8], Kazuhisa Fujita[3], Tomohiro Usui[3] (1.College of Agriculture, Tamagawa University, 2.Tokyo University of Pharmacy and Life Science, 3.Japan Aerospace Exploration Agency, 4.Nagaoka University of Technology, 5.Tokyo University of Technology, 6.Yokohama National University, 7.Hiroshima University, 8.Fukuoka Institute of Technology)

[PPS04-P07] Development of a Mars Web-GIS for viewing multiple kinds of spectral data from orbiters

*Yuya Matsubara[1], Hironori Fukuchi[1], Yoshiko Ogawa[1], Yohei Hayashi[2] (1.The University of Aizu, 2.National Astronomical Observatory of Japan)

[PPS04-P08] Visualization and Analysis of the Surface of Mars with NASA's Mars Trek Portal

*Brian Hamilton Day[1], Emily Law[2] (1.NASA Solar System Exploration Research Virtual Institute, NASA Ames Research Center, 2.NASA Jet Propulsion Laboratory, California Institute of Technology)

[PPS04-P09] Increase in Dissolved Iron Concentration from Fayalite by UltravioletA・C Irradiation

*Nobuo Komori[1] (1.The United Graduate School of Education Tokyo Gakugei University)

[PPS04-P10] Small-scale ridges newly identified on the equatorial region of the Phobos nearside

*Ryodo Hemmi[1], Hiroshi Kikuchi[1], Hideaki Miyamoto[1] (1.The University of Tokyo)

[PPS04-P11] Development of a compact Muography instrument for future Mars exploration missions

*Hiroaki Kamiyoshihara[1], Tetsuro Ninomiya[1], Yuri Yoshihara[1], Kenji Shimazoe[1], Hiroyuki Takahashi[1], Hiroyuki Tanaka[1], Hideaki Miyamoto[1] (1.University of Tokyo)

[E] Poster | P (Space and Planetary Sciences)：P-PS Planetary Sciences

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_4

[P-PS04] Mars and Mars system: results from a broad spectrum of Mars studies and aspects for future missions

convener:Hideaki Miyamoto(University of Tokyo), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Ayako Matsuoka(Research Division for Space Plasma, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Sushil K Atreya(University of Michigan Ann Arbor)

[PPS04-P01] Observation of the O_2^+ first negative band (1,0) emissions in the Mars ionosphere with a visible spectrograph on Haleakala T60

*Toshihisa Suzuki[1], Masato Kagitani[1], Takeshi Sakanoi[1] (1.PPARC, Graduate School of Science, Tohoku University)

[PPS04-P02] Search of shallow subsurface reflectors around RSLs in Martian Chryse and Acidalia planitiae by the MRO/SHARAD public data

*Aina Oura[1], Yasumasa Kasaba[1], Atsushi Kumamoto[1], Rina Noguchi[2], Tomohiro Usui[2], Ken Ishiyama[2], Chihiro Uemura[3] (1.Tohoku University, 2.Institute of Space and Astronautical Science, 3.SOKENDAI)

[PPS04-P03] Detecting surface changes on Mars using principle component analysis of repeat imagery

*Reid Parsons[1], Hideaki Miyamoto[1] (1.University of Tokyo)

[PPS04-P04] Evaluation of the detectability of hydrated salts on recurring slope lineae on Mars.

*Shoko Imamura[1,2], Yasuhito Sekine[2], Hiroyuki Kurokawa[2] (1.University of Tokyo, 2.Earth-Life Science Institute, Tokyo Institute of Technology)

[PPS04-P05] Frequency of ice sheet growth recorded on Mons Pavonis, Mars

*Tomohiro Kanzaki[1], Reid Parsons[1,2], Ryodo Hemmi[1], Hideaki Miyamoto[1] (1.University of Tokyo, 2.Fitchburg State University)

[PPS04-P06] Development of Life Detection Microscope (LDM) for *in situ* imaging of living cells on Mars surface

*Yoshitaka Yoshimura[1], Akihiko Yamagishi[2], Takehiko Satoh[3], Atsuo Miyakawa[2], Eiichi Imai[4], Satoshi Sasaki[5], Kensei Kobayashi[6], Yoko Kebukawa[6], Tomoka Okada[6], Keigo Enya[3], Hikaru Yabuta[7], Takeshi Naganuma[7], Hajime Mita[8], Kazuhisa Fujita[3], Tomohiro Usui[3] (1.College of Agriculture, Tamagawa University, 2.Tokyo University of Pharmacy and Life Science, 3.Japan Aerospace Exploration Agency, 4.Nagaoka University of Technology, 5.Tokyo University of Technology, 6.Yokohama National University, 7.Hiroshima University, 8.Fukuoka Institute of Technology)

[PPS04-P07] Development of a Mars Web-GIS for viewing multiple kinds of spectral data from orbiters

*Yuya Matsubara[1], Hironori Fukuchi[1], Yoshiko Ogawa[1], Yohei Hayashi[2] (1.The University of Aizu, 2.National Astronomical Observatory of Japan)

[PPS04-P08] Visualization and Analysis of the Surface of Mars with NASA's Mars Trek Portal

*Brian Hamilton Day[1], Emily Law[2] (1.NASA Solar System Exploration Research Virtual Institute, NASA Ames Research Center, 2.NASA Jet Propulsion Laboratory, California Institute of Technology)

[PPS04-P09] Increase in Dissolved Iron Concentration from Fayalite by UltravioletA・C Irradiation

*Nobuo Komori[1] (1.The United Graduate School of Education Tokyo Gakugei University)

[PPS04-P10] Small-scale ridges newly identified on the equatorial region of the Phobos nearside

*Ryodo Hemmi[1], Hiroshi Kikuchi[1], Hideaki Miyamoto[1] (1.The University of Tokyo)

[PPS04-P11] Development of a compact Muography instrument for future Mars exploration missions

*Hiroaki Kamiyoshihara[1], Tetsuro Ninomiya[1], Yuri Yoshihara[1], Kenji Shimazoe[1], Hiroyuki Takahashi[1], Hiroyuki Tanaka[1], Hideaki Miyamoto[1] (1.University of Tokyo)

[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[P-PS07] Formation and evolution of planetary materials in the Solar System

convener:Yoko Kebukawa(Faculty of Engineering, Yokohama National University), Wataru Fujiya(Ibaraki University, College of Science), Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Megumi Matsumoto(Graduate School of Science, Tohoku University), Chairperson:Megumi Matsumoto, Wataru Fujiya

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PPS07-01] Investigation of sugars in meteorites

★Invited Papers

*Yoshihiro Furukawa[1], Yoshito Chikaraishi[2], Naohiko Ohkouchi[3], Nanako O. Ogawa[3], Tomoki Nakamura[1] (1.Graduate School of Science, Tohoku University, 2.Institute of Low Temperature Science, Hokkaido University, 3.JAMSTEC)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PPS07-02] Establishment of ice sublimation method for detection of soluble organic matter contained in Antarctic micrometeorites in Antarctic glacier ice

*Yui Ishikawa[1], Yamamoto Kota[1], Hiroshi Naraoka[2], Toru Yada[3], Tatsuaki Okada[1,3] (1.Graduate School of Science, The University of Tokyo, 2.Graduate School of Science, Kyushu University, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PPS07-03] Magnesium-containing organic compounds in the Tagish Lake and Murchison meteorites.

*Minako Hashiguchi[1], Hiroshi Naraoka[2,1] (1.Research Center for Planetary Trace Organic Compounds, Kyushu University, 2.Department of Earth and Planetary Sciences, Kyushu University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PPS07-04] Interactions between minerals and organic materials on thermal processes in meteorite parent bodies

*Naoki Hirakawa[1], Yoko Kebukawa[1], Kensei Kobayashi[1] (1.Yokohama National University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PPS07-05] Organic matter in carbonaceous chondrite lithologies of Almahata Sitta meteorite, a polymict ureilite

*Yoko Kebukawa[1], Michael Zolensky[2], Cyrena Anne Goodrich[3], Motoo Ito[4], Nanako O. Ogawa[5], Yoshinori Takano[5], Naohiko Ohkouchi[5], Hiroki Suga[9], Matthew Marcus[6], David Kilcoyne[6], Takuji Ohigashi[7], Zia Rahman[2], Muawia H. Shaddad[8], Kensei Kobayashi[1] (1.Yokohama National University, 2.NASA Johnson Space Center, 3.Lunar and Planetary Institute, 4.Kochi Institute for Core Sample Research JAMSTEC, 5.Japan Agency for Marine-Earth Science and Technology, 6.Lawrence Berkeley National Laboratory, 7.Institute for Molecular Science, 8.University of Khartoum, 9.The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PPS07-06] Thermal Evolution of Hydrous Minerals on Small Bodies: To Understand Thermal Histories of Ryugu and Bennu

*Kana Ishimaru[1], Shogo Tachibana[2] (1.University of Tokyo, 2.UTokyo Organization for Planetary and Space Science, University of Tokyo)

[E] Poster | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_2

[P-EM14] Recent Advances in Ionosphere Observation and Modeling for Monitoring and Forecast

convener:Yang-Yi Sun(China University of Geosciences), CHIYEN LIN(Center for Astronautical Physics and Engineering, National Central University, TAIWAN), MINYANG CHOU(National Cheng Kung University)

[PEM14-P01] **The Daytime and Nighttime Mapped Whistler Plasmapause Observed by DEMETER**

*ChaoYen Chen[1,2], Tiger J. Y. Liu[1,2,3] (1.Institute of Space Science, National Central University, Taiwan, 2.Center for Astronautical Physics and Engineering, National Central University, Taiwan , 3.Center for Space and Remote Sensing Research, National Central University, Taiwan)

[PEM14-P02] Global Plasma Density Irregularity Distributions Observed by Advanced Ionospheric Probe Onboard FORMOSAT-5 Satellite

*Chi-Kuang Chao[1], Yi-Wun Chen[1] (1.Graduate Institute of Space Science, National Central University)

[PEM14-P03] The First Result on Ionospheric Space Weather of FORMOSAT-5/AIP Ion Density

*FU-YUAN CHANG[1], JANN-YENQ Liu[1], Chi-Kuang Chao[1] (1.National Central University)

[PEM14-P04] **The global total electron content reconstruction in the local time frame**

*Tsung-Che Tsai[1,2], Hau-Kun Jhuang[3], Lou-Chuang Lee[3,4,5], Yi-Ying Ho[4] (1.National Center for High-Performance Computing, National Applied Research Laboratories, Hsinchu, Taiwan, 2.Department of Civil Engineering, National Chiao Tung University, Hsinchu, Taiwan., 3.Department of Geoscience, National Taiwan University, Taipei, Taiwan., 4.Institute of Earth Science, Academia Sinica, Nankang, Taipei, Taiwan., 5.Institute of Space Science, National Central University, Jhongli, Taiwan.)

[PEM14-P05] Research on impacts of power line harmonic radiation on ionospheric parameters

*Qiang Guo[1], Jing Wu[1], Ling Yang[1] (1.Beihang University)

[PEM14-P06] **Analysis of cosmic rays dynamics and ionospheric parameters during increased solar activity and magnetic storms**

*Oksana Mandrikova[1], Yurii Polozov[1], Bogdana Mandrikova[1,2] (1.Institute of Cosmophysical Research and Radio Wave Propagation, Far Eastern Branch of the Russian Academy of Sciences, 2.Saint Petersburg Electrotechnical University "LETI")

[PEM14-P07] King Tidal Effects on the ionosphere during the period of 2000 to 2017

*TsungYu Wu[1], JANN-YENQ Liu[1] (1.Institute of Space Science, NCU, Taiwan)

[PEM14-P08] SuperDARN near range echoes and higher resolution measurement - recent improvement and future

*Akira Sessai Yukimatu[1,2] (1.National Institute of Polar Research, 2.SOKENDAI)

[PEM14-P09] **The ionospheric wave peak structures in the low latitude region and their seasonal, and solar activity dependence based on Global Ionosphere Maps**

*Hau-Kun Jhuang[1], Tsung-Che Tsai[2,3], Lou-Chuang Lee[1,4,5], Yi-Ying Ho[4] (1.Department of Geosciences, National Taiwan University, Taipei, Taiwan, 2.National Center for High-performance Computing, National Applied Research Laboratories, Hsinchu, Taiwan, 3.Department of Civil Engineering, National Chiao Tung University, Hsinchu, Taiwan, 4.Institute of Earth Science, Academia Sinica, Nankang, Taipei, Taiwan, 5.Institute of Space Science, National Central University, Jhongli, Taiwan)

[E] Poster | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_5

[P-EM14] Recent Advances in Ionosphere Observation and Modeling for Monitoring and Forecast

convener:Yang-Yi Sun(China University of Geosciences), CHIYEN LIN(Center for Astronautical Physics and Engineering, National Central University, TAIWAN), MINYANG CHOU(National Cheng Kung University)

[PEM14-P01] **The Daytime and Nighttime Mapped Whistler Plasmapause Observed by DEMETER**

*ChaoYen Chen[1,2], Tiger J. Y. Liu[1,2,3] (1.Institute of Space Science, National Central University, Taiwan, 2.Center for Astronautical Physics and Engineering, National Central University, Taiwan , 3.Center for Space and Remote Sensing Research, National Central University, Taiwan)

[PEM14-P02] Global Plasma Density Irregularity Distributions Observed by Advanced Ionospheric Probe Onboard FORMOSAT-5 Satellite

*Chi-Kuang Chao[1], Yi-Wun Chen[1] (1.Graduate Institute of Space Science, National Central University)

[PEM14-P03] The First Result on Ionospheric Space Weather of FORMOSAT-5/AIP Ion Density

*FU-YUAN CHANG[1], JANN-YENQ Liu[1], Chi-Kuang Chao[1] (1.National Central University)

[PEM14-P04] **The global total electron content reconstruction in the local time frame**

*Tsung-Che Tsai[1,2], Hau-Kun Jhuang[3], Lou-Chuang Lee[3,4,5], Yi-Ying Ho[4] (1.National Center for High-Performance Computing, National Applied Research Laboratories, Hsinchu, Taiwan, 2.Department of Civil Engineering, National Chiao Tung University, Hsinchu, Taiwan., 3.Department of Geoscience, National Taiwan University, Taipei, Taiwan., 4.Institute of Earth Science, Academia Sinica, Nankang, Taipei, Taiwan., 5.Institute of Space Science, National Central University, Jhongli, Taiwan.)

[PEM14-P05] Research on impacts of power line harmonic radiation on ionospheric parameters

*Qiang Guo[1], Jing Wu[1], Ling Yang[1] (1.Beihang University)

[PEM14-P06] **Analysis of cosmic rays dynamics and ionospheric parameters during increased solar activity and magnetic storms**

*Oksana Mandrikova[1], Yurii Polozov[1], Bogdana Mandrikova[1,2] (1.Institute of Cosmophysical Research and Radio Wave Propagation, Far Eastern Branch of the Russian Academy of Sciences, 2.Saint Petersburg Electrotechnical University "LETI")

[PEM14-P07] King Tidal Effects on the ionosphere during the period of 2000 to 2017

*TsungYu Wu[1], JANN-YENQ Liu[1] (1.Institute of Space Science, NCU, Taiwan)

[PEM14-P08] SuperDARN near range echoes and higher resolution measurement - recent improvement and future

*Akira Sessai Yukimatu[1,2] (1.National Institute of Polar Research, 2.SOKENDAI)

[PEM14-P09] **The ionospheric wave peak structures in the low latitude region and their seasonal, and solar activity dependence based on Global Ionosphere Maps**

*Hau-Kun Jhuang[1], Tsung-Che Tsai[2,3], Lou-Chuang Lee[1,4,5], Yi-Ying Ho[4] (1.Department of Geosciences, National Taiwan University, Taipei, Taiwan, 2.National Center for High-performance Computing, National Applied Research Laboratories, Hsinchu, Taiwan, 3.Department of Civil Engineering, National Chiao Tung University, Hsinchu, Taiwan, 4.Institute of Earth Science, Academia Sinica, Nankang, Taipei, Taiwan, 5.Institute of Space Science, National Central University, Jhongli, Taiwan)

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 201B 2F

[P-EM14] Recent Advances in Ionosphere Observation and Modeling for Monitoring and Forecast

convener:Yang-Yi Sun(China University of Geosciences), CHIYEN LIN(Center for Astronautical Physics and Engineering, National Central University, TAIWAN), MINYANG CHOU(National Cheng Kung University), Chairperson:Yang-Yi Sun

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PEM14-01] New In-situ Ion Composition and Velocity Observations in the Topside Ionosphere from the Swarm-E Ion Mass Spectrometer

★Invited Papers

*Andrew W Yau[1] (1.University of Calgary)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PEM14-02] **Spatial-time features and dynamics of ionospheric disturbances during magnetic storms in 2015-2018**

★Invited Papers

*Oksana Mandrikova[1], Nadezhda Fetisova[1], Yurii Polozov[1,2] (1.Institute of Cosmophysical Research and Radio Wave Propagation, Far Eastern Branch of the Russian Academy of Sciences, 2.Kamchatka State Technical University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PEM14-03] Estimating 2D neutral wind patterns using line-of-sight data from multiple Scanning Doppler Imagers

*Heikki Vanhamaki[1], Shin-ichiro Oyama[1,2], Mark Conde[3], Anita Aikio[1], Lei Cai[4], Ilkka Virtanen[1] (1.University of Oulu, Finland, 2.Institute for Space-Earth Environmental Research, Nagoya University, Japan, 3.Geophysical Institute, University of Alaska Fairbanks, US, 4.KTH Royal Institute of Technology, Sweden)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PEM14-04] **Comparison of empirical models for the location of the ionospheric middle-latitude trough in the nighttime**

*Sarah Park[1], Khan-Hyuk Kim[1] (1.School of Space Research, Kyung Hee University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PEM14-05] Research on nonlinear cross-modulation of power line emission and other very low frequency radiations in the ionosphere

*Ling Yang[1], Jing Wu[1], Qiang Guo[1] (1.Beihang University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PEM14-06] Ionospheric variation induced by 21 August 2017 total solar eclipse detected by Global Ionospheric Specification

*CHIYEN LIN[1,2], JANN-YENQ Liu[1,2,3], Charles Lin[4] (1.Center for Astronautical Physics and Engineering, National Central University, Taiwan, 2.Graduate Institute of Space Science, National Central University, Taiwan, 3.Center for Space and Remote Sensing Research, National Central University, Taiwan, 4.Department of Earth Science, National Cheng Kung University, Taiwan)

[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 201B 2F

[P-EM14] Recent Advances in Ionosphere Observation and Modeling for Monitoring and Forecast

convener:Yang-Yi Sun(China University of Geosciences), CHIYEN LIN(Center for Astronautical Physics and Engineering, National Central University, TAIWAN), MINYANG CHOU(National Cheng Kung University), Chairperson:CHI-YEN LIN

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PEM14-07] Spatial gradients in the ionospheric delays (TECs) and scintillations associated with plasma bubbles

★Invited Papers

*Susumu Saito[1], Takayuki Yoshihara[1] (1.Electronic Navigation Research Institute, National Institute of Maritime, Port, and Aviation Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PEM14-08] Temporal and spatial variation of GPS TEC and phase scintillation during substorms and auroral breakups

*Paul Prikryl[1,2], James M. Weygand[3], Reza Ghoddousi-Fard[4], P. Thayyil Jayachandran[1], David R. Themens[1], Anthony M. McCaffrey[1], Bharat S. R. Kunduri[5], Emma Spanswick[6], Yongliang Zhang[7], Akira Sessai Yukimatu[8] (1.Physics Dept. of University of New Brunswick, Canada, 2.Geomagnetic Laboratory Natural Resources Canada, 3.Earth Planetary and Space Sciences, University of California, USA, 4.Canadian Geodetic Survey Natural Resources Canada , 5.Bradley Dept. of Electrical and Computer Engineering, Virginia Tech, USA, 6.Dept. of Physics and Astronomy of University of Calgary, Canada, 7.Johns Hopkins University Applied Physics Laboratory, USA, 8.National Institute of Polar Research, Japan)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PEM14-09] IGS ROTI Maps extension toward Southern Hemisphere and low latitudes

*Iurii Cherniak[1,2], Irina Zakharenkova[2], Andrzej Krankowski[2] (1.COSMIC Program Office, University Corporation for Atmospheric Research, 2.University of Warmia and Mazury in Olsztyn)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PEM14-10] Durations of ionospheric gradients and plasma bubbles as ionospheric threats to GBAS

*MAHO NAKAMURA[1], Susumu Saito[1], Takayuki Yoshihara[1] (1.Electronic Navigation Research Institute)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PEM14-11] Ionospheric Space Weather Data Product of FORMOSAT-7/COSMIC-2

★Invited Papers

*Charles Lin[1], P. K. Rajesh[1], CHIYEN LIN[2,3], Chia-Hung Chen[1], Jia-Ting Lin[1] (1.Department of Earth Sciences, National Cheng Kung University, 2.Center for Astronautical Physics and Engineering, National Central University, Taoyuan 32001, Taiwan, 3.Graduate Institute of Space Science, National Central University, Taoyuan 32001, Taiwan)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PEM14-12] **Vertical structure of ionosphere perturbed by large earthquake and tsunami**

*Yang-Yi Sun[1], XiangXiang Yan[1], Tao Yu[1], JANN-YENQ Liu[2] (1.China University of Geosciences (Wuhan), 2.National Central University)

[J] Poster | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_2

[P-EM19] Frontiers in the solar physics

convener:Shinsuke Imada(Institute for Space-Earth Environmental Research, Nagoya University), Takaaki Yokoyama(School of Science, University of Tokyo), Toshifumi Shimizu(Institute of Space and Astronautical Science, JAXA), Yukio Katsukawa(National Astronomical Observatory of Japan, National Institute of Natural Sciences)

[PEM19-P01] Onset Mechanism of the Largest Solar Flare in Solar Cycle 24

★Invited Papers

*Yumi Bamba[1,2], Satoshi Inoue[1], Shinsuke Imada[1], Kanya Kusano[1] (1.Institute for Space-Earth Environmental Research/Nagoya University, 2.Institute if Space and Astronautical Science/Japan Aerospace Exploration Agency)

[PEM19-P02] Infrequent Occurrence of Significant Linear Polarization in H-alpha Solar Flares

*Tomoko Kawate[1], Yoichiro Hanaoka[2] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.National Astronomical Observatory of Japan)

[PEM19-P03] Statistical study of solar flares simultaneously observed with RHESSI and Nobeyama Radioheliograph

*Satoshi Masuda[1], Sam Krucker[2,3], Stephen White[4] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.University of Applied Sciences Northwestern Switzerland, 3.University of California, Berkeley, 4.Air Force Research Laboratory)

[PEM19-P04] Microwave turn-over frequencies and emission temperatures for white-light solar flares

*Kosuke Tsuruda[1], Kyoko Watanabe[1], Satoshi Masuda[2], Säm Krucker[3] (1.National Defense Academy , 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.University of Applied Sciences Northwestern Switzerland, UC Berkeley)

[PEM19-P05] Stellar flare of a close binary system monitored by the Hisaki satellite during the NICER-Hisaki Observing Campaign 2018-2019

*Tomoki Kimura[1], Wataru Iwakiri[2], Atsushi Yamazaki[3], Go Murakami[3], Fuminori Tsuchiya[4], Kazuo Yoshioka[5], Shin Toriumi[6], Hajime Kita[3], Masaki Kuwabara[3] (1.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 2.Faculty of Science and Engineering, Chuo University, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 4.Planetary Plasma and Atmospheric Research Center, Tohoku University, 5.Department of Complexity Science and Engineering, University of Tokyo, 6.National Astronomical Observatory of Japan)

[PEM19-P06] Solar Neutron and Gamma-ray Observations with a 3U CubeSat

*Kazutaka Yamaoka[1], Hiroyasu Tajima[1], Kikuko Miyata[2], Takaya Inamori[2], Yoshinori Sasai[1], Kazuhiro Nakazawa[3], Satoshi Masuda[1], Koji Matsushita[4], Kazuya Itoh[4], Hiromitsu Takahashi[5], Kyoko Watanabe[6] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.School of Engineering, Nagoya University, 3.School of Science, Nagoya University, 4.Technical Center, Nagoya University, 5.School of Science, Hiroshima University, 6.National Defence Academy of Japan)

[PEM19-P07] Magnetic Flux Cancelation as the Buildup and Trigger Mechanism for CME-Producing Eruptions in two Small Active Regions

*Alphonse Sterling[1], Ronald L Moore[1,2], Navdeep K Panesar[1] (1.NASA/MSFC, 2.CSPAR, University of Alabama Huntsville)

[PEM19-P08] Estimation of turbulent pumping in the solar near-surface convection zone

*Haruhisa Iijima[1], Hideyuki Hotta[2], Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Graduate School of Science, Chiba University)

[PEM19-P09] Evaluation of the influence of the next solar cycle by sunspots using surface flux transport model

*Yusaku Watanabe[1], Shinsuke Imada[1], Haruhisa Iijima[1], Yoshizumi Miyoshi[1] (1.Institute for Space–Earth Environmental Research, Nagoya University)

[PEM19-P10] The image analysis of sunspot sketches in Dalton minimum(the early 1800s)

*SHOMA UNEME[1], Shinsuke Imada[1], Hisashi Hayakawa[2], Yoshizumi Miyoshi[1] (1.Nagoya University Institute for Space Earth for Enviornmental research, 2.Osaka University School of Letters)

[PEM19-P11] Observations of Photospheric Magnetic Structure below a Solar Dark Filament

*Takaaki Yokoyama[1], Yukio Katsukawa[2], Masumi Shimojo[2] (1.School of Science, The University of Tokyo, 2.National Astronomical Observatory of Japan)

[PEM19-P12] Science Target of Solar-C_EUVST Mission

*Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

[J] Poster | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_6

[P-EM19] Frontiers in the solar physics

convener:Shinsuke Imada(Institute for Space-Earth Environmental Research, Nagoya University), Takaaki Yokoyama(School of Science, University of Tokyo), Toshifumi Shimizu(Institute of Space and Astronautical Science, JAXA), Yukio Katsukawa(National Astronomical Observatory of Japan, National Institute of Natural Sciences)

[PEM19-P01] Onset Mechanism of the Largest Solar Flare in Solar Cycle 24

★Invited Papers

*Yumi Bamba[1,2], Satoshi Inoue[1], Shinsuke Imada[1], Kanya Kusano[1] (1.Institute for Space-Earth Environmental Research/Nagoya University, 2.Institute if Space and Astronautical Science/Japan Aerospace Exploration Agency)

[PEM19-P02] Infrequent Occurrence of Significant Linear Polarization in H-alpha Solar Flares

*Tomoko Kawate[1], Yoichiro Hanaoka[2] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.National Astronomical Observatory of Japan)

[PEM19-P03] Statistical study of solar flares simultaneously observed with RHESSI and Nobeyama Radioheliograph

*Satoshi Masuda[1], Sam Krucker[2,3], Stephen White[4] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.University of Applied Sciences Northwestern Switzerland, 3.University of California, Berkeley, 4.Air Force Research Laboratory)

[PEM19-P04] Microwave turn-over frequencies and emission temperatures for white-light solar flares

*Kosuke Tsuruda[1], Kyoko Watanabe[1], Satoshi Masuda[2], Säm Krucker[3] (1.National Defense Academy , 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.University of Applied Sciences Northwestern Switzerland, UC Berkeley)

[PEM19-P05] Stellar flare of a close binary system monitored by the Hisaki satellite during the NICER-Hisaki Observing Campaign 2018-2019

*Tomoki Kimura[1], Wataru Iwakiri[2], Atsushi Yamazaki[3], Go Murakami[3], Fuminori Tsuchiya[4], Kazuo Yoshioka[5], Shin Toriumi[6], Hajime Kita[3], Masaki Kuwabara[3] (1.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 2.Faculty of Science and Engineering, Chuo University, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 4.Planetary Plasma and Atmospheric Research Center, Tohoku University, 5.Department of Complexity Science and Engineering, University of Tokyo, 6.National Astronomical Observatory of Japan)

[PEM19-P06] Solar Neutron and Gamma-ray Observations with a 3U CubeSat

*Kazutaka Yamaoka[1], Hiroyasu Tajima[1], Kikuko Miyata[2], Takaya Inamori[2], Yoshinori Sasai[1], Kazuhiro Nakazawa[3], Satoshi Masuda[1], Koji Matsushita[4], Kazuya Itoh[4], Hiromitsu Takahashi[5], Kyoko Watanabe[6] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.School of Engineering, Nagoya University, 3.School of Science, Nagoya University, 4.Technical Center, Nagoya University, 5.School of Science, Hiroshima University, 6.National Defence Academy of Japan)

[PEM19-P07] Magnetic Flux Cancelation as the Buildup and Trigger Mechanism for CME-Producing Eruptions in two Small Active Regions

*Alphonse Sterling[1], Ronald L Moore[1,2], Navdeep K Panesar[1] (1.NASA/MSFC, 2.CSPAR, University of Alabama Huntsville)

[PEM19-P08] Estimation of turbulent pumping in the solar near-surface convection zone

*Haruhisa Iijima[1], Hideyuki Hotta[2], Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Graduate School of Science, Chiba University)

[PEM19-P09] Evaluation of the influence of the next solar cycle by sunspots using surface flux transport model

*Yusaku Watanabe[1], Shinsuke Imada[1], Haruhisa Iijima[1], Yoshizumi Miyoshi[1] (1.Institute for Space–Earth Environmental Research, Nagoya University)

[PEM19-P10] The image analysis of sunspot sketches in Dalton minimum(the early 1800s)

*SHOMA UNEME[1], Shinsuke Imada[1], Hisashi Hayakawa[2], Yoshizumi Miyoshi[1] (1.Nagoya University Institute for Space Earth for Enviornmental research, 2.Osaka University School of Letters)

[PEM19-P11] Observations of Photospheric Magnetic Structure below a Solar Dark Filament

*Takaaki Yokoyama[1], Yukio Katsukawa[2], Masumi Shimojo[2] (1.School of Science, The University of Tokyo, 2.National Astronomical Observatory of Japan)

[PEM19-P12] Science Target of Solar-C_EUVST Mission

*Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

[J] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM19] Frontiers in the solar physics

convener:Shinsuke Imada(Institute for Space-Earth Environmental Research, Nagoya University), Takaaki Yokoyama(School of Science, University of Tokyo), Toshifumi Shimizu(Institute of Space and Astronautical Science, JAXA), Yukio Katsukawa(National Astronomical Observatory of Japan, National Institute of Natural Sciences), Chairperson:Shinsuke Imada

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PEM19-01] The Sun-Geospace connection: toward the 25th solar cycle

★Invited Papers

*Yoshizumi Miyoshi[1], Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PEM19-02] Unsolved problems of the solar wind turbulence

★Invited Papers

*Munehito Shoda[1] (1.Graduate School of Science, University of Tokyo)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PEM19-03] The Solar-C_EUVST Epsilon mission

*Toshifumi Shimizu[1] (1.Institute of Space and Astronautical Science, JAXA)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PEM19-04] Advanced Observations of the Solar Atmosphere by a Balloon-Borne Telescope SUNRISE-3

*Yukio Katsukawa[1], Carlos Quintero Noda[2], Masahito Kubo[1], Hirohisa Hara[1], Toshifumi Shimizu[2] (1.National Astronomical Observatory of Japan, 2.ISAS/JAXA)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PEM19-05] Radiation magnetohydrodynamic modeling of solar coronal dynamics

*Haruhisa Iijima[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PEM19-06] Detection and energy derivation of nano-flares based on deep learning

*Toshiki Kawai[1], Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

[J] Oral | P (Space and Planetary Sciences)：P-AE Astronomy & Extrasolar Bodies

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 105 1F

[P-AE20] Exoplanet

convener:Masahiro Ikoma(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Norio Narita(University of Tokyo), Chairperson:Norio Narita(University of Tokyo), Masahiro Ikoma(The University of Tokyo)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PAE20-01] Gravitational Microlensing Surveys for Exoplanets

★Invited Papers

*Daisuke Suzuki[1] (1.Institute of Space and Astronautical Science / Japan Aerospace Exploration Agency)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PAE20-02] Doppler planet searches targeting stars in solar neighborhood

★Invited Papers

*Bunei Sato[1] (1.Tokyo Institute of Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PAE20-03] Development of MuSCAT3 for ground-based follow-up observations of TESS candidate exoplanets

*Norio Narita[1,2,3], Akihiko Fukui[2], Masahiro Ikoma[2], Motohide Tamura[1,2], Nobuhiko Kusakabe[1], Mayuko Mori[2], Tomoyasu Yamamuro[4] (1.Astrobiology Center, 2.University of Tokyo, 3.JST, 4.OptCraft)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PAE20-04] Effect of metallicity and eddy diffusion on transmission spectra of hazy exoplanet atmospheres

*Yui Kawashima[1], Masahiro Ikoma[2] (1.SRON Netherlands Institute for Space Research, 2.The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PAE20-05] Mineral clouds of fluffy aggregates: how they form in exoplanetary atmospheres and influence transmission spectra

*Kazumasa Ohno[1], Satoshi Okuzumi[1], Ryo Tazaki[2] (1.Department of Earth and Planetary Science, Tokyo Institute of Technology, 2.Astronomical Institute, Tohoku University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PAE20-06] Orbital Architecture of Planetary Systems Formed by Giant Impacts

★Invited Papers

*Eiichiro Kokubo[1] (1.Division of Theoretical Astronomy, National Astronomical Observatory of Japan)

[J] Oral | P (Space and Planetary Sciences)：P-AE Astronomy & Extrasolar Bodies

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 105 1F

[P-AE20] Exoplanet

convener:Masahiro Ikoma(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Norio Narita(University of Tokyo), Chairperson:Masahiro Ikoma(The University of Tokyo), Norio Narita(University of Tokyo)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PAE20-07] Thermal convection in the mantle of super-Earths

★Invited Papers

*Takehiro Miyagoshi[1], Masanori Kameyama[2], Masaki Ogawa[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Ehime University, 3.University of Tokyo)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PAE20-08] Atmospheric escape from M-dwarf exoplanets and implications for habitability

*Chuanfei Dong[1] (1.Princeton University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PAE20-09] Theoretical emission spectra of hot rocky super-Earths: Lack of alkali metals due to atmospheric escape

*Yuichi Ito[1,2], Masahiro Ikoma[2] (1.Department of Cosmosciences, Graduate school of Science, Hokkaido University, 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PAE20-10] Hot Rocky Super-Earths atmospheres, a revision of gas phase metal chemistry and the relevance of reverse chemistry

*Sebastian Danielache[1,2], Takahashi Yuta[1], Miguel Yamila[3], Simoncini Eugenio[4], Grassi Tommaso[5] (1.Department of Materials & Life Sciences, Faculty of Science & Technology, Sophia University, 2.Tokyo Institute of Technology, Earth-Life Institute , 3.Leiden Observatory, Leiden University, 4.Simoncini Telai Gambassi Terme, 5.University Observatory Munich, Ludwig-Maximilians-University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PAE20-11] A Climate of tidally locked terrestrial exoplanets

*Takanori Kodama[1] (1.University of Bordeaux)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PAE20-12] Current status of WSO-UV/UVSPEX for discovery of Earth-like planets

*Shingo Kameda[1], Osada Naoya[1], Takanori Kodama[2], Go Murakami[3], Keigo Enya[3], Masahiro Ikoma[4], Norio Narita[5], Naoki Terada[6], Hitoshi Fujiwara[7] (1.School of Science, Rikkyo University, 2.University of Bordeaux, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 4.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 5.National Astronomical Observatory of Japan, 6.Graduate School of Science, Tohoku University, 7.Faculty of Science and Technology, Seikei University)

[J] Poster | P (Space and Planetary Sciences)：P-AE Astronomy & Extrasolar Bodies

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_4

[P-AE20] Exoplanet

convener:Masahiro Ikoma(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Norio Narita(University of Tokyo)

[PAE20-P01] An interpretation of exoplanet masses and orbital radii with a theoretical model of gas giant formation

*Kiyoka Murase[1], Hidekazu Tanaka[1] (1.TOHOKU UNIVERSITY)

[PAE20-P02] Impact of resonance trapping of planetesimals during planetary migration on metallicities of close-in gas giants

*Sho Shibata[1], Masahiro Ikoma[1] (1.Graduate School of Science, The University of Tokyo)

[PAE20-P03] Theoretical modeling of hydrogen line emission from accreting gas giants: comparison with observations of LkCa15b and PDS70b

*Yuhiko Aoyama[1], Masahiro Ikoma[1], Gabriel-Dominique Marleau[2], Christoph Mordasini[3] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Institute for Astronomy and Astrophysics, Eberhard Karls University of Tubingen, 3.Physics Institute, University of Bern)

[PAE20-P04] Design of a Lyman alpha telescope LAICA2 for exoplanetary exploration

*Toru Muraoka[1], Go Murakami[2], Shingo Kameda[1] (1.Rikkyo University, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

[PAE20-P05] Numerical experiments on thermal convection of highly compressible fluids: Influences for mantle convection of super-Earths

*Masanori Kameyama[1,2] (1.Geodynamics Research Center, Ehime University, 2.Japan Agency for Marine-Earth Science and Technology)

[PAE20-P06] Impact of Stellar Superflares on Planetary Habitability

*Yosuke Alexandre Yamashiki[1], Hiroyuki Maehara[2], Vladimir Airapetian[5], Yuta Notsu[3], Tatsuhiko Sato[4], Shota Notsu[3], Ryusuke Kuroki[1], keiya murashima[8], Hiroaki Sato[7], Kosuke Namekata[3], Takanori Sasaki[3], Thomas Scott[9], Hina Bando[3], Subaru Nashimoto[8], Fuka Takagi[6], Cassandra Ling[1], Daisaku Nogami[3], Kazunari Shibata[10] (1.Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University, 2.National Astronomical Observatory of Japan, 3.Department of Astronomy, Kyoto University, 4.Japan Atomic Energy Agency, 5.NASA / GSFC, 6.Faculty of Agriculture, Kyoto University, 7.Faculty of Engineering, Kyoto University, 8.Faculty of Science, Kyoto University, 9.Interface Analysis Centre, University of Bristol, 10.Astronomical Observatory, Kyoto University)

[PAE20-P07] Studies of atmospheric structure in new very-hot Jupiter with high-resolution transmission spectroscopy

*Kiyoe Kawauchi[1], Bun'ei Sato[1], Norio Narita[2], Teruyuki Hirano[1], Yui Kawashima[3] (1.Tokyo Institute of Technology, 2.Tokyo University, 3.SRON - Netherlands Institute for Space Research)

[PAE20-P08] Doppler Tomographic Analysis for the Planetary Orbital Precession of WASP-33b

*Noriharu Watanabe[1], Norio Narita[2], Marshall C. Johnson[3] (1.The Graduate University for Advanced Studies, 2.The University of Tokyo, 3.The Ohio State University)

[PAE20-P09] TESS Follow-up Observation with IRSF/SIRIUS

*Mayuko Mori[1], Norio Narita[1,2], Jerome Pitogo de Leon[1], Taku Nishiumi[3], Akihiko Fukui[1], Motohide Tamura[1,2], Nobuhiko Kusakabe[2], Kumiko Morihana[4] (1.The University of Tokyo, 2.Astrobiology Center, NINS, 3.Kyoto Sangyo University, 4.Nagoya University)

[PAE20-P10] Status of the Multi-band Cameras for Transiting Exoplanets MuSCAT1,2 and New Results in 2018

*Akihiko Fukui[1], Norio Narita[2], Nobuhiko Kusakabe[2], Motohide Tamura[2,1], Kiyoe Kawauchi[1], John Livingston[1], Jerome de Leon[1], Noriharu Watanabe[3], Yuka Terada[1], Mayuko Mori[1], Taku Nishiumi[4] (1.The University of Tokyo, 2.Astrobiology Center, 3.SOKENDAI, 4.Kyoto Sangyo University)

[J] Poster | P (Space and Planetary Sciences)：P-AE Astronomy & Extrasolar Bodies

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_7

[P-AE20] Exoplanet

convener:Masahiro Ikoma(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Norio Narita(University of Tokyo)

[PAE20-P01] An interpretation of exoplanet masses and orbital radii with a theoretical model of gas giant formation

*Kiyoka Murase[1], Hidekazu Tanaka[1] (1.TOHOKU UNIVERSITY)

[PAE20-P02] Impact of resonance trapping of planetesimals during planetary migration on metallicities of close-in gas giants

*Sho Shibata[1], Masahiro Ikoma[1] (1.Graduate School of Science, The University of Tokyo)

[PAE20-P03] Theoretical modeling of hydrogen line emission from accreting gas giants: comparison with observations of LkCa15b and PDS70b

*Yuhiko Aoyama[1], Masahiro Ikoma[1], Gabriel-Dominique Marleau[2], Christoph Mordasini[3] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Institute for Astronomy and Astrophysics, Eberhard Karls University of Tubingen, 3.Physics Institute, University of Bern)

[PAE20-P04] Design of a Lyman alpha telescope LAICA2 for exoplanetary exploration

*Toru Muraoka[1], Go Murakami[2], Shingo Kameda[1] (1.Rikkyo University, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

[PAE20-P05] Numerical experiments on thermal convection of highly compressible fluids: Influences for mantle convection of super-Earths

*Masanori Kameyama[1,2] (1.Geodynamics Research Center, Ehime University, 2.Japan Agency for Marine-Earth Science and Technology)

[PAE20-P06] Impact of Stellar Superflares on Planetary Habitability

*Yosuke Alexandre Yamashiki[1], Hiroyuki Maehara[2], Vladimir Airapetian[5], Yuta Notsu[3], Tatsuhiko Sato[4], Shota Notsu[3], Ryusuke Kuroki[1], keiya murashima[8], Hiroaki Sato[7], Kosuke Namekata[3], Takanori Sasaki[3], Thomas Scott[9], Hina Bando[3], Subaru Nashimoto[8], Fuka Takagi[6], Cassandra Ling[1], Daisaku Nogami[3], Kazunari Shibata[10] (1.Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University, 2.National Astronomical Observatory of Japan, 3.Department of Astronomy, Kyoto University, 4.Japan Atomic Energy Agency, 5.NASA / GSFC, 6.Faculty of Agriculture, Kyoto University, 7.Faculty of Engineering, Kyoto University, 8.Faculty of Science, Kyoto University, 9.Interface Analysis Centre, University of Bristol, 10.Astronomical Observatory, Kyoto University)

[PAE20-P07] Studies of atmospheric structure in new very-hot Jupiter with high-resolution transmission spectroscopy

*Kiyoe Kawauchi[1], Bun'ei Sato[1], Norio Narita[2], Teruyuki Hirano[1], Yui Kawashima[3] (1.Tokyo Institute of Technology, 2.Tokyo University, 3.SRON - Netherlands Institute for Space Research)

[PAE20-P08] Doppler Tomographic Analysis for the Planetary Orbital Precession of WASP-33b

*Noriharu Watanabe[1], Norio Narita[2], Marshall C. Johnson[3] (1.The Graduate University for Advanced Studies, 2.The University of Tokyo, 3.The Ohio State University)

[PAE20-P09] TESS Follow-up Observation with IRSF/SIRIUS

*Mayuko Mori[1], Norio Narita[1,2], Jerome Pitogo de Leon[1], Taku Nishiumi[3], Akihiko Fukui[1], Motohide Tamura[1,2], Nobuhiko Kusakabe[2], Kumiko Morihana[4] (1.The University of Tokyo, 2.Astrobiology Center, NINS, 3.Kyoto Sangyo University, 4.Nagoya University)

[PAE20-P10] Status of the Multi-band Cameras for Transiting Exoplanets MuSCAT1,2 and New Results in 2018

*Akihiko Fukui[1], Norio Narita[2], Nobuhiko Kusakabe[2], Motohide Tamura[2,1], Kiyoe Kawauchi[1], John Livingston[1], Jerome de Leon[1], Noriharu Watanabe[3], Yuka Terada[1], Mayuko Mori[1], Taku Nishiumi[4] (1.The University of Tokyo, 2.Astrobiology Center, 3.SOKENDAI, 4.Kyoto Sangyo University)

[E] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Kazuo Yoshioka(The University of Tokyo), Mitsunori Ozaki(Kanazawa University)

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[PCG21-01] Current status and instrument development plan for future lunar exploration missions

★Invited Papers

*Makiko Ohtake[1] (1.Japan Aerospace Exploration Agency)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[PCG21-02] Development of a Neutral Particle TOF-MS for Future Solar System Explorations

*Daichi Fukuyama[1], Yoshifumi Saito[2], Kazushi Asamura[2], Shoichiro Yokota[3] (1.The university of Tokyo, 2.ISAS/JAXA, 3.Osaka University)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[PCG21-03] Development of Orbitrap Mass Spectrometer for in-situ measurements in solar system explorations

*Oya Kawashima[1], Satoshi Kasahara[1], Yoshifumi Saito[4], Shoichiro Yokota[2], Masafumi Hirahara[3], Seiji Sugita[1] (1.The university of tokyo, 2.Osaka University, 3.Nagoya University, 4.ISAS / JAXA)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[PCG21-04] A high-voltage pulsed power supply for on-site mass spectrometry in future solar system explorations

*Shoichiro Yokota[1], Yosuke Kawai[1], Jun Aoki[1], Yoshifumi Saito[2], Makiko Ohtake[2], Tatsuaki Okada[2] (1.Graduate School of Science, Osaka University, 2.ISAS/JAXA)

10:05 AM - 10:20 AM JST | 1:05 AM - 1:20 AM UTC

[PCG21-05] Development of DESTINY$^+$ Dust Analyzer and its expected science return

*Takayuki Hirai[1], Masanori Kobayashi[1], Tomoko Arai[1], Hiroshi Kimura[1], Ralf Srama[2], Harald Krueger[3] (1.Chiba Institute of Technology, Planetary Exploration Research Center, 2.University of Stuttgart, 3.Max Planck Institute for Solar System Research)

[E] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Satoshi Kasahara , Mitsunori Ozaki(Kanazawa University)

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[PCG21-06] Satellite mission: PhoENiX (Physics of Energetic and Non-thermal plasmas in the X (= magnetic reconnection) region)

★Invited Papers

*Noriyuki Narukage[1], Mitsuo Oka[2], Yasushi Fukazawa[3], Keiichi Matsuzaki[4], Shin Watanabe[4], Taro Sakao[4], Sin-nosuke Ishikawa[5], Kouichi Hagino[6], Ikuyuki Mitsuishi[5], Tsunefumi Mizuno[3], Iku Shinohara[4], Masumi Shimojo[1], Shinsuke Takasao[5], Hiroshi Tanabe[7], Munetaka UENO[8], Tadayuki Takahashi[9], Takeshi Takashima[4], Masayuki Ohta[4] (1.National Astronomical Observatory of Japan, 2.Space Sciences Laboratory, The University of California, Berkeley, 3.Hiroshima University, 4.Japan Aerospace Exploration Agency, 5.Nagoya University, 6.Tokyo University of Science, 7.The University of Tokyo, 8.Kobe University, 9.Kavli Institute for the Physics and Mathematics of the Universe)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[PCG21-07] Development of ion drift velocity analyzer for sounding rocket and low-altitude satellite

*Takumi Abe[1], Shigeto Watanabe[2], Akinori Saito[3] (1.Department of Solar System Sciences, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Hokkaido Information University, 3.Graduate School of Science, Kyoto University)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[PCG21-08] **SS-520-3 Sounding Rocket Experiment Targeting the Ion Outflow in the Polar Cusp / Aurora**

*Yoshifumi Saito[1], Yasunobu Ogawa[2], Hirotsugu Kojima[3] (1.Department of Solar System Science, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.National Institute of Polar Research, 3.Research Institute for Sustainable Humanosphere, Kyoto University)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[PCG21-09] **Development of the chip implemented as high-speed current detection circuits for particle sensors**

*Motoyuki Kikukawa[2], Takahiro Zushi[2], Hirotsugu Kojima[2], Yoshifumi Saito[1] (1.JAXA, 2.Kyoto University)

11:50 AM - 12:10 PM JST | 2:50 AM - 3:10 AM UTC

[PCG21-10] GEO-X (GEOspace X-ray imager) : Imaging the dayside solar wind-terrestrial magnetosphere interaction

★Invited Papers

*Yuichiro Ezoe[1], Yoshizumi Miyoshi[2], Satoshi Kasahara[3], Ryu Funase[3], Harunori Nagata[4], Hiroshi Nakajima[5], Kumi Ishikawa[6], Atsushi Yamazaki[6], Hiroshi Hasegawa[6], Junko Hiraga[7], Masaki Fujimoto[6], Kazuhisa Mitsuda[6], Munetaka Ueno[8], Hiroyuki Koizumi[3], Yasuhiro Kawakatsu[6], Takahiro Iwata[6], Hironori Sahara[1] (1.Tokyo Metropolitan University, 2.Nagoya University, 3.University of Tokyo, 4.Hokkaido University, 5.Kanto Gakuin University, 6.ISAS/JAXA, 7.Kansei Gakuin University, 8.Kobe University)

[E] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Shingo Kameda, Mitsunori Ozaki(Kanazawa University)

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[PCG21-11] **Debye: a multi-spacecraft mission to solve the electron energization problem in the solar wind**

★Invited Papers

*Fouad Sahraoui[2], Robert T Wicks[1], Daniel Verscharen[1], The Debye The Debye Team (1.Mullard Space Science Laboratory, Department of Space and Climate Physics, University College London, UK, 2.LPP CNRS Ecole Polytechnique)

2:05 PM - 2:25 PM JST | 5:05 AM - 5:25 AM UTC

[PCG21-12] Comet Interceptor mission to a dynamically new comet

★Invited Papers

*Shinnaka Yoshiharu[1], Shingo Kameda[2], Satoshi Kasahara[3], Hideyo Kawakita[1], Masanori Kobayashi[4], Ryu Funase[3], Ichiro Yoshikawa[3], Jones H Geraint[5], Colin Snodgrass[6] (1.Kyoto Sangyo University, 2.Rikkyo University, 3.The University of Tokyo, 4.Chiba Institute of Technology, 5.UCL, 6.The Open University)

2:25 PM - 2:45 PM JST | 5:25 AM - 5:45 AM UTC

[PCG21-13] The concept of AI3 and impactors

★Invited Papers

*Koji Wada[1], Jakob Deller[2], Jessica Agarwal[2], Hans Martin Braun[3], Kieran Carroll[4], Hannah Goldberg[5], Martin Jutzi[6], Özgür Karatekin[7], Tomáš Kohout[8], Sampsa Pursiainen[9], Birgit Ritter[7], Olaf Roders[2], Francisco da Silva Pais Cabral[10], Fredrik Sjoberg[11], Mika Takala[9], Esa Vilenius[2], Patrick Bambach[2], Ryo Ishimaru[1], Yutaka WADA[1], Masahiko Arakawa[12], Takanao Saiki[13] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Max Planck Institute, Göttingen, 3.RST Radar System Technik, 4.Gedex Systems Inc, 5.GOMSpace, 6.University of Bern, 7.Royal Observatory of Belgium, 8.University of Helsinki, 9.Tampere University of Technology, 10.GMV, 11.OHB, 12.Kobe University, 13.JAXA)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PCG21-14] Observational Techniques for Energy Transport Verification in Space Plasmas and Waves Developed in the FACTORS Mission

*Masafumi Hirahara[1], Hirotsugu Kojima[2], Naritoshi Kitamura[3], Kazushi Asamura[4], Yoshifumi Saito[4] (1.Institute of Space-Earth Environmental Research, Nagoya University, 2.Research Institute of Sustainable Humanosphere, Kyoto University, 3.Graduate School of Science, The University of Tokyo, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PCG21-15] Current status of Life Detection Microscope (LDM) for Mars surface exploration

*Yoshitaka Yoshimura[1], Akihiko Yamagishi[2], Takehiko Satoh[3], Atsuo Miyakawa[2], Eiichi Imai[4], Satoshi Sasaki[5], Kensei Kobayashi[6], Yoko Kebukawa[6], Tomoka Okada[6], Keigo Enya[3], Hikaru Yabuta[7], Takeshi Naganuma[7], Hajime Mita[8], Kazuhisa Fujita[3], Tomohiro Usui[3] (1.College of Agriculture, Tamagawa University, 2.Tokyo University of Pharmacy and Life Science, 3.Japan Aerospace Exploration Agency, 4.Nagaoka University of Technology, 5.Tokyo University of Technology, 6.Yokohama National University, 7.Hiroshima University, 8.Fukuoka Institute of Technology)

[E] Poster | P (Space and Planetary Sciences)：P-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_5

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo)

[PCG21-P01] Visible and ultraviolet imagers for auroral and airglow observations by FACTORS - a future satellite mission for understanding the coupling and transportation processes in the upper atmosphere

*Takeshi Sakanoi[1], Masafumi Hirahara[2], Takuo T. Tsuda[3], Kazushi Asamura[4], Yoshizumi Miyoshi[2], Tomo-Hiko Watanabe[5], Takanori Nishiyama[6], Shin-ichiro Oyama[2,7], Yoshifumi Saito[4], Keisuke Hosokawa[3], Hirotsugu Kojima[8], Naritoshi Kitamura[9], Yasunobu Ogawa[5], Masatoshi Yamauchi[10], Ayako Matsuoka[4], Naoshi Yagi[1], Fukizawa Fukizawa[1], Genki Ishizawa[11] (1.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2.ISEE, Nagoya University, 3.Graduate School of Informatics and Engineering, School of Informatics and Engineering, The University of Electro-Communications, 4.ISAS/JAXA, 5.Graduate School of Science, Nagoya University, 6.National Institute for Polar Research, 7.University of Oulu, Finland, 8.RISH, Kyoto University, 9.Graduate School of Science, the University of Tokyo, Tokyo, 10.IRF Kiruna, Sweden, 11.Graduate School of Science, Tohoku University)

[PCG21-P02] Spatio-temporal analysis of flash aurora using Convolutional Neural Network

*Toki Genda[1], Takumi Inoue[1], Mitsunori Ozaki[1], Satoshi Yagitani[1], Imamura Kousuke[1], Kazuo Shiokawa[2], Yoshizumi Miyoshi[2], Shin-ichiro Oyama[2], Ryuho Kataoka[3], Yusuke Ebihara[4], Keisuke Hosokawa[5] (1.Kanazawa Univ., 2.Nagoya Univ., 3.NIPR, 4.Kyoto Univ., 5.UEC)

[PCG21-P03] Study on the pulse noise removal technique for Pc1 geomagnetic pulsations on the ground by signal processing

*Fumiya Komase[1], Tomohiro Inoue[1], Mitsunori Ozaki[1], Satoshi Yagitani[1], Kazuo Shiokawa[2], Masahito Nose[2], Tsutomu Nagatsuma[3] (1.Kanazawa Univ., 2.Nagoya Univ., 3.NICT)

[PCG21-P04] Application of magneto-impedance sensor to geomagnetic field measurements

*Masahito Nose[1], Reiko Nomura[2], Kazushi Asamura[3], Hitoshi Aoyama[4], Takeshi Kawano[4], Ayako Matsuoka[3], Kentarou Kitamura[5], Yukinobu Koyama[6], Haruhisa Matsumoto[7], Masafumi Hirahara[1] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.National Astronomical Observatory of Japan, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 4.Aichi Steel Corporation, 5.National Institute of Technology, Tokuyama College, 6.National Institute of Technology, Oita College, 7.Research and Development Directorate, Japan Aerospace Exploration Agency)

[PCG21-P05] Observation of the Ionospheric Currents by the CubeSat at the Low and Middle Latitude

*Kentarou Kitamura[1], Kazumasa Imai[2], Taku Takada[2], Manabu Shinohara[3], Makoto Wakabayashi[4], KOSEN Space Collaboration Group (1.National Institute of Technology, Tokuyama Collge, 2.National Institute of Technology, Kochi Collge, 3.National Institute of Technology, Kagoshima Collge, 4.National Institute of Technology, Niihama Collge)

[PCG21-P06] Basic study on miniaturization of electric field instrument for plasma wave observations by ASIC technology

*Yuya Tokunaga[1], Mitsunori Ozaki[1], Keigo Ishisaka[2], Hirotsugu Kojima[3], Satoshi Yagitani[1], Takahiro Zushi[3] (1.Kanazawa University, 2.Toyama Prefectural University, 3.Kyoto University)

[PCG21-P07] Evaluation of radiation tolerance of electronics parts used for the ultra-small mission

*Riku Katsuse[1], Kazuo Yoshioka[1], Masaki Kuwabara[2], Reina Hikida[1], Shogo Arao[1], Ichiro Yoshikawa[1] (1.The university of Tokyo , 2.Institute of Space and Astronautical Science)

[PCG21-P08] A method to quantitatively evaluate Non-evaporable-getter pump for use in space science mission

*Seiya Nishimura[1], Ichiro Yoshikawa[1], Kazuo Yoshioka[1], Shogo Arao[1], Zhang Tianxu[1] (1.The university of tokyo)

[PCG21-P09] Interpretation on slight asymmetry of analyzer characteristics of MIA onboard the Mio by means of a model calculation of 3-D potential distribution

*Wataru Miyake[1], Yoshifumi Saito[2], Shoichiro Yokota[3] (1.Tokai University, 2.ISAS, 3.Osaka University)

[PCG21-P10] Construction of impact testing machine for small satellites and evaluation of mechanical resistance of MCPs by the impact test

*Junya Fukuba[1] (1.Graduate school of Tokyo)

[PCG21-P11] Innovative design of double-shell type energy analyzer for simultaneous electron and ion measurements in space

*Tomomi Takei[1], Masafumi Hirahara[1] (1.Institute for space-earth environmental research, Nagoya university)

[PCG21-P12] Microsatellite Development and Education of Space Science and Technology at Kanazawa University

*Tomohiko Imachi[1], Satoshi Yagitani[1], Daisuke Yonetoku[1], Yoshiya Kasahara[1], Tatsuya Sawano[1], Makoto Arimoto[1], Yoshitaka Goto[1], Mitsunori Ozaki[1], Ryuichi Fujimoto[1] (1.Kanazawa University)

[PCG21-P13] Attitude Control System for Kanazawa-SAT3 Microsatellite

Takuya Nakajima[1], Yuuki Yasuda[1], Hirofumi Segawa[1], *Tomohiko Imachi[1], Satoshi Yagitani[1], Yoshiya Kasahara[1], Daisuke Yonetoku[1], Tatsuya Sawano[1], Makoto rimoto[1] (1.Kanazawa University)

[PCG21-P14] Communications System and Antennas for Kanazawa-SAT3 Microsatellite

Teruya Minamoto[1], Koyo Ina[1], Kohei Kawagoshi[1], *Tomohiko Imachi[1], Satoshi Yagitani[1], Yoshitaka Goto[1], Daisuke Yonetoku[1], Yoshiya Kasahara[1], Tatsuya Sawano[1], Makoto Arimoto[1] (1.Kanazawa University)

[PCG21-P15] Development of micrometeoroid impact sensor within a multi-layered insulation (CLOTH) onboard 6U deep-space explorer EQUULEUS

*Takayuki Hirai[1], Hajime Yano[2], Ritsuko Jitsukawa[3], Eigo Ishioka[3], Haruki Nakano[3], Kazuyoshi Arai[3], Sunao Hasegawa[2] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Faculty of Science and Engineering, Hosei University)

[PCG21-P16] Breadboard model of asteroid tracking system for DESTINY$^+$ mission

*Peng Hong[1], Ko Ishibashi[1], Shunsuke Sato[2], Kazutoshi Takemura[3], Kotaro Fujiwara[4], Kanako Machii[5], Hiroyuki Toyota[2], Kazutaka Nishiyama[2], Masatsugu Otsuki[2], Osamu Okudaira[1], Takeshi Takashima[2] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Department of Applied Mechanics, Graduate School of Fundamental Science and Engineering, Waseda University, 4.Division of Mechanical and Space Engineering, Graduate School of Engineering, Hokkaido University, 5.Department of Mechanical Engineering and Intelligent Systems, Faculty of Informatics and Engineering, The University of Electro-Communications)

[PCG21-P17] Development of telescopic camera (TENGOO) performance evaluation device in MMX

*Hiroki Kato[1], Shingo Kameda[1], Keigo Enya[2], Osada Naoya[1] (1.Rikkyo University, 2.Japan Aerospace Exploration Agency)

[PCG21-P18] Observation Plans in the Cruising-Phase of the Solar Power Sail: OKEANOS

*Takahiro Iwata[1], Shuji Matsuura[2], KOHJI TSUMURA[3], Hajime Yano[1], Takayuki Hirai[4], Ayako Matsuoka[1], Daisuke Yonetoku[5], Tatehiro Mihara[6], Tatsuaki Okada[1], Osamu Mori[1], Toshihiro Chujo[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Kwansei Gakuin University, 3.Tohoku University, 4.Chiba Institute of Technology, 5.Kanazawa University, 6.RIKEN)

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5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_8

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*Masahito Nose[1], Reiko Nomura[2], Kazushi Asamura[3], Hitoshi Aoyama[4], Takeshi Kawano[4], Ayako Matsuoka[3], Kentarou Kitamura[5], Yukinobu Koyama[6], Haruhisa Matsumoto[7], Masafumi Hirahara[1] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.National Astronomical Observatory of Japan, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 4.Aichi Steel Corporation, 5.National Institute of Technology, Tokuyama College, 6.National Institute of Technology, Oita College, 7.Research and Development Directorate, Japan Aerospace Exploration Agency)

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[PCG21-P15] Development of micrometeoroid impact sensor within a multi-layered insulation (CLOTH) onboard 6U deep-space explorer EQUULEUS

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[PCG21-P16] Breadboard model of asteroid tracking system for DESTINY$^+$ mission

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[PCG21-P17] Development of telescopic camera (TENGOO) performance evaluation device in MMX

*Hiroki Kato[1], Shingo Kameda[1], Keigo Enya[2], Osada Naoya[1] (1.Rikkyo University, 2.Japan Aerospace Exploration Agency)

[PCG21-P18] Observation Plans in the Cruising-Phase of the Solar Power Sail: OKEANOS

*Takahiro Iwata[1], Shuji Matsuura[2], KOHJI TSUMURA[3], Hajime Yano[1], Takayuki Hirai[4], Ayako Matsuoka[1], Daisuke Yonetoku[5], Tatehiro Mihara[6], Tatsuaki Okada[1], Osamu Mori[1], Toshihiro Chujo[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Kwansei Gakuin University, 3.Tohoku University, 4.Chiba Institute of Technology, 5.Kanazawa University, 6.RIKEN)

[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 201B 2F

[P-CG23] Origin and evolution of materials in space

convener:Hitoshi Miura(Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University), Hideko Nomura(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Takafumi Ootsubo(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Aki Takigawa(Division of Earth and Planetary Science, Kyoto University), Chairperson:Ryo Tazaki, Aoi Takahashi

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PCG23-01] Origin of cosmic dust: Galaxy-scale perspective

★Invited Papers

*Akio Inoue[1,2] (1.Osaka Sangyo University, 2.Waseda University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PCG23-02] SPICA and future infrared observations of cosmic matters

★Invited Papers

*Issei Yamamura[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PCG23-03] Engineering first light of a new mid-infrared instrument MIMIZUKU

*Takafumi Kamizuka[1], Takashi Miyata[1], Shigeyuki Sako[1], Ryou Ohsawa[1], Masahito S. Uchiyama[1], Tomohiro Mori[1], Yutaka Yoshida[1] (1.Institute of Astronomy, School of Science, the University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PCG23-04] Properties and space exposure of Quenched Nitrogen-included Carbonaceous Composite (QNCC)

*Izumi Endo[1], Itsuki Sakon[1], Takashi Onaka[1], Yoko Kebukawa[2], Kensei Kobayashi[2], MITA Hajime[4], Hajime Yano[3] (1.University of Tokyo, 2.Yokohama National University, 3.ISAS/JAXA, 4.Fukuoka Institute of Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PCG23-05] Shape dependence of dust absorption opacity in the Rayleigh domain

*Ryo Tazaki[1], Hidekazu Tanaka[1] (1.Astronomical Institute, Tohoku University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PCG23-06] Modeling of the H_2 ortho-para spin conversion on grain surfaces in star- and planet-forming regions

*Kenji Furuya[1], W. M. C. Sameera[2], Tetsuya Hama[2], Naoki Watanabe[2], Yuri Aikawa[3] (1.Center for Computer Sciences, University of Tsukuba, 2.Institute of Low Temperature Science, Hokkaido University,, 3.The University of Tokyo)

[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 201B 2F

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10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PCG23-07] Thermal processes of primary silicate dust in protoplanetary disk: Constraints from oxygen isotope exchange kinetics between amorphous silicate and water vapor

★Invited Papers

*Daiki Yamamoto[1], Shogo Tachibana[2], Noriyuki Kawasaki[1], Minami Kuroda[1], Naoya Sakamoto[3], Hisayoshi Yurimoto[1,4] (1.Department of Natural History Sciences ,Hokkaido University, 2.UTokyo Organization for Planetary Space Science, The University of Tokyo , 3.Creative Research Institution, Hokkaido University , 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PCG23-08] Birth-place of comet 17P/Holmes from its mass fractions of minerals

★Invited Papers

*Shinnaka Yoshiharu[1], Takafumi Ootsubo[2], Hideyo Kawakita[1], Mitsuru Yamaguchi[1], Mitsuhiko Honda[3], Jun-ichi Watanabe[4] (1.Kyoto Sangyo University, 2.JAXA/ISAS, 3.Kurume University, 4.NAOJ)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PCG23-09] Comparison of grain properties in interplanetary dust from different types of parent bodies by mid-infrared spectroscopic observations with AKARI

*Aoi Takahashi[1], Takafumi Ootsubo[2], Hideo Matsuhara[2], Fumihiko Usui[3], Itsuki Sakon[4], Hiroki Chihara[5] (1.The Graduate University for Advanced Studies, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Kobe University, 4.University of Tokyo, 5.Osaka Sangyo University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PCG23-10] Formation of forsterite crystal induced by ultraviolet irradiation of water ice ice on amorphous Mg_2SiO_4 particles

*Akira Kouchi[1], Yuki Kimura[1], Yasuhiro Oba[1], Tetsuya Hama[1], Naoki Watanabe[1], Shogo Tachibana[2], Akira Tsuchiyama[3], Satomi Enju[3], Takafumi Ootsubo[4] (1.Institute of Low Temperature Science, Hokkaido University, 2.UTokyo Organization for Planetary and Space Science, University of Tokyo, 3.Graduate School of Science, Kyoto University, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PCG23-11] Condensation experiments in the sytem Fe-Mg-Si-O-S using induction thermal plasma: implication to GEMS forming condition

*Satomi Enju[1], Hayate Kawano[1], Hisashi Komaki[2], Akira Tsuchiyama[1] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2.JEOL Ltd.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PCG23-12] **The initial abundance of ^{92}Nb in the outer solar system.**

*Yuki Hibiya[1,2], Tsuyoshi Iizuka[2], Hatsuki Enomoto[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.The University of Tokyo)

[J] Poster | P (Space and Planetary Sciences)：P-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_6

[P-CG23] Origin and evolution of materials in space

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[PCG23-P01] Infrared spectrum of planetary-nebula analyzed by pure-carbon graphene molecule

*Norio Ota[1] (1.University of Tsukuba,Graduate school of pure and applied sciences)

[PCG23-P02] Theory of Self-induced Desorption of Molecules from Cold Dust Surface

Tetsuo Yamamoto[1], *Hitoshi Miura[2], Osama M. Shalabiea[3] (1.Hokkaido University, 2.Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University, 3.Cairo University)

[PCG23-P03] Synthesis of GEMS analogue particles by condensation experiments in the system Mg-Fe-Si-S-Al-Ca-Ni-O

*Yuto Imura[1], Satomi Enju[1], Hayate Kawano[1], Akira Tsuchiyama[1] (1. Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University)

[PCG23-P04] Laboratory Detection of New Absorption Bands of Interstellar-Molecule Candidate Thiophenoxy Radical

Haruka Sato[1], Mayu Negishi[1], *Mitsunori Araki[1], Takahiro Oyama[1], Koichi Tsukiyama[1] (1.Department of Chemistry, Faculty of Science Division I, Tokyo University of Science)

[PCG23-P05] Structure and dynamics of interface between forsterite glass and amorphous ice

*Ayane Kubo[1], Junya Nishizawa[1], Tomoko Ikeda-Fukazawa[1] (1.Department of Applied Chemistry, Meiji University, Japan)

[PCG23-P06] Effect of Space Weathering on Identification of Organic Matter on Celestial Body Surface Using Ultraviolet Wavelength Region Spectrum

*Shogo Arao[1], Ichiro Yoshikawa[2], Kazuo Yoshioka[2], Itsuki Sakon[1], Reina Hikida[1], Izumi Endo[1], Riku Katsuse[2] (1.Graduate School of Science, The University of Tokyo, 2.Graduate School of Frontier Sciences, The University of Tokyo)

[PCG23-P07] Detection of CH_3CN in Envelope around Sagittarius B2(N)

*Mitsunori Araki[1], Shuro Takano[2], Takahiro Oyama[1], Nobuhiko Kuze[3], Kazuhisa Kamegai[4], Koichi Tsukiyama[1] (1.Tokyo University of Science, 2.Nihon University, 3.Sophia University, 4.National Astronomical Observatory of Japan)

[J] Poster | P (Space and Planetary Sciences)：P-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_9

[P-CG23] Origin and evolution of materials in space

convener:Hitoshi Miura(Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University), Hideko Nomura(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Takafumi Ootsubo(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Aki Takigawa(Division of Earth and Planetary Science, Kyoto University)

[PCG23-P01] Infrared spectrum of planetary-nebula analyzed by pure-carbon graphene molecule

*Norio Ota[1] (1.University of Tsukuba,Graduate school of pure and applied sciences)

[PCG23-P02] Theory of Self-induced Desorption of Molecules from Cold Dust Surface

Tetsuo Yamamoto[1], *Hitoshi Miura[2], Osama M. Shalabiea[3] (1.Hokkaido University, 2.Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University, 3.Cairo University)

[PCG23-P03] Synthesis of GEMS analogue particles by condensation experiments in the system Mg-Fe-Si-S-Al-Ca-Ni-O

*Yuto Imura[1], Satomi Enju[1], Hayate Kawano[1], Akira Tsuchiyama[1] (1. Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University)

[PCG23-P04] Laboratory Detection of New Absorption Bands of Interstellar-Molecule Candidate Thiophenoxy Radical

Haruka Sato[1], Mayu Negishi[1], *Mitsunori Araki[1], Takahiro Oyama[1], Koichi Tsukiyama[1] (1.Department of Chemistry, Faculty of Science Division I, Tokyo University of Science)

[PCG23-P05] Structure and dynamics of interface between forsterite glass and amorphous ice

*Ayane Kubo[1], Junya Nishizawa[1], Tomoko Ikeda-Fukazawa[1] (1.Department of Applied Chemistry, Meiji University, Japan)

[PCG23-P06] Effect of Space Weathering on Identification of Organic Matter on Celestial Body Surface Using Ultraviolet Wavelength Region Spectrum

*Shogo Arao[1], Ichiro Yoshikawa[2], Kazuo Yoshioka[2], Itsuki Sakon[1], Reina Hikida[1], Izumi Endo[1], Riku Katsuse[2] (1.Graduate School of Science, The University of Tokyo, 2.Graduate School of Frontier Sciences, The University of Tokyo)

[PCG23-P07] Detection of CH_3CN in Envelope around Sagittarius B2(N)

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_3

[A-AS06] Progress in dense observation and numerical modeling of micro-scale meteorology

convener:Junshi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Kentaro Araki(Meteorological Research Institute), Jun-ichi Furumoto(Research Institute for Sustainable Humanosphere, Kyoto University), Kuniaki Higashi(Research Institute for Sustainable Humanosphere, Kyoto University Metroweather Co., Ltd.)

[AAS06-P01] **Assimilation of Wind Profiling Radar Data in GRAPES-MESO Model System**

*Dan Wang[1], Zhen Ruan[2] (1.Numerical Weather Prediction Center, China Meteorological Administration, 2.Chinese Academy of Meteorological Sciences)

[AAS06-P02] Exploring aerosol-cloud interaction using satellite retrievals

*Xiaoyan Ma[1], hailing Jia[1], Johannes Quaas[2] (1.Nanjing University of Information Science and Technology, 2.Universität Leipzig)

[AAS06-P03] Analysis of an EF4 supercell thunderstorm mesoscale structure

*HaiGuang Zhou[1] (1.Chinese Academy of Meteorological Sciences)

[AAS06-P04] A Case Study of Seeding Condition Potential Forecast Using Cloud Resolving Model

*Yueqin SHI[1] (1.Chinese Academy of Meteorological Sciences)

[AAS06-P05] Route planning and communication of drone fleet for microscale weather observation ×

*Yuichi Yaguchi[1], Shuzo Nakano[3], Akira Sasaki[6], Masayuki Itaha[4], Tatsuya Iyobe[5], Kazuhiko Yamagishi[2] (1.The University of Aizu, 2.e-Robotics Fukushima Co., Ltd., 3.East-Japan Accounting Center Co., Ltd., 4.Japan Environment Research Co., Ltd., 5.Iyobe Shoji Ltd., 6.GClue Inc.)

[AAS06-P06] Wind speed estimation by low-cost visibility meter network

*Yui Kobayashi [1,2], Kyoya Watanabe[1,3], Nobuyasu Naruse[1,4], Yukihiro Takahashi[1,5] (1.Global Science Campus, Hokkaido University, 2.Faculty of Science, Tohoku University, 3.School of Engineering, Hokkaido University, 4.Faculty of Medicine, Shiga University of Medical Science, 5.Graduate School of Science, Hokkaido University)

[AAS06-P07] Regional characteristics of periodic variations of temperature and wind in Tokyo under wintertime nocturnal clear and weak wind conditions

*Nakajima Ko[1,2], Hideo Takahashi[2], Nobumitsu Tsunematsu[1] (1.Tokyo Metropolitan Research Institute for Environmental Protection, Tokyo Environmental Public Service Corporation, 2.Tokyo Metropolitan University)

[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_10

[A-AS06] Progress in dense observation and numerical modeling of micro-scale meteorology

convener:Junshi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Kentaro Araki(Meteorological Research Institute), Jun-ichi Furumoto(Research Institute for Sustainable Humanosphere, Kyoto University), Kuniaki Higashi(Research Institute for Sustainable Humanosphere, Kyoto University Metroweather Co., Ltd.)

[AAS06-P01] **Assimilation of Wind Profiling Radar Data in GRAPES-MESO Model System**

*Dan Wang[1], Zhen Ruan[2] (1.Numerical Weather Prediction Center, China Meteorological Administration, 2.Chinese Academy of Meteorological Sciences)

[AAS06-P02] Exploring aerosol-cloud interaction using satellite retrievals

*Xiaoyan Ma[1], hailing Jia[1], Johannes Quaas[2] (1.Nanjing University of Information Science and Technology, 2.Universität Leipzig)

[AAS06-P03] Analysis of an EF4 supercell thunderstorm mesoscale structure

*HaiGuang Zhou[1] (1.Chinese Academy of Meteorological Sciences)

[AAS06-P04] A Case Study of Seeding Condition Potential Forecast Using Cloud Resolving Model

*Yueqin SHI[1] (1.Chinese Academy of Meteorological Sciences)

[AAS06-P05] Route planning and communication of drone fleet for microscale weather observation ×

*Yuichi Yaguchi[1], Shuzo Nakano[3], Akira Sasaki[6], Masayuki Itaha[4], Tatsuya Iyobe[5], Kazuhiko Yamagishi[2] (1.The University of Aizu, 2.e-Robotics Fukushima Co., Ltd., 3.East-Japan Accounting Center Co., Ltd., 4.Japan Environment Research Co., Ltd., 5.Iyobe Shoji Ltd., 6.GClue Inc.)

[AAS06-P06] Wind speed estimation by low-cost visibility meter network

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[AAS06-P07] Regional characteristics of periodic variations of temperature and wind in Tokyo under wintertime nocturnal clear and weak wind conditions

*Nakajima Ko[1,2], Hideo Takahashi[2], Nobumitsu Tsunematsu[1] (1.Tokyo Metropolitan Research Institute for Environmental Protection, Tokyo Environmental Public Service Corporation, 2.Tokyo Metropolitan University)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 301A 3F

[A-AS06] Progress in dense observation and numerical modeling of micro-scale meteorology

convener:Junshi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Kentaro Araki(Meteorological Research Institute), Jun-ichi Furumoto(Research Institute for Sustainable Humanosphere, Kyoto University), Kuniaki Higashi(Research Institute for Sustainable Humanosphere, Kyoto University Metroweather Co., Ltd.), Chairperson:Junshi Ito(The University of Tokyo), Kentaro Araki(Meteorological Research Institute)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AAS06-01] A Linear Array of Wind and Pressure Sensors for High Resolution in situ Measurements in Winter Tornadoes

★Invited Papers

*Kusunoki Kenichi[1], Hanako Inoue[1], Naoki Ishitsu[2], Chusei Fujiwara[3] (1.Meteorological Research Institute, 2.Alpha-denshi Co., Ltd. / Meteorological Research Institute, 3.East Japan Railway Company)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AAS06-02] Mesoscale fixed point weather observation architecture by Drone fleet

*Yuichi Yaguchi[1], Masayuki Itaha[4], Shuzo Nakano[3], Kazuhiko Yamagishi[2], Tatsuya Iyobe[5] (1.The University of Aizu, 2.e-Robotics Fukushima Co., Ltd., 3.East-Japan Accounting Center Co., Ltd., 4.Japan Environment Research Co., Ltd., 5.Iyobe Shoji Ltd.)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AAS06-03] Potential of dense weather event observation using surface optical fiber cable and DAS technology

*Tsunehisa KIMURA[1] (1.Schlumberger)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AAS06-04] Case study of environmental conditions and cloud microphysical properties of winter convective clouds developed in the Kanto plain

*Kentaro Araki[1], Shinsuke Satoh[2], Takuya Tajiri[1] (1.Meteorological Research Institute, 2.National Institute of Information and Communications Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AAS06-05] Numerical simulation of the urban effect on the atmospheric boundary layer structure in Tokyo using the SPUC urban canopy scheme

*Naoko Seino[1] (1.Meteorological Research Institute)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AAS06-06] Surface layer model for instantaneous wind speeds designed by deep learning

*Junshi Ito[1,2], Hideaki Mouri[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo , 2.Meteorological Research Institute)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 303 3F

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo)

9:10 AM - 9:30 AM JST | 12:10 AM - 12:30 AM UTC

[AOS09-01] **Model Spectra for Turbulence Below and Above the Ozmidov Wavenumber**

★Invited Papers

*Eric L Kunze[1] (1.NorthWest Research Associates Redmond)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AOS09-02] **A new parameterization of turbulent mixing caused by tidal flow over abyssal rough bathymetry**

*Toshiyuki Hibiya[1] (1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AOS09-03] Development of CTD-attached microstructure measurements and basin-scale turbulence distribution in the North Pacific

*Ichiro Yasuda[1], Yasutaka Goto[2], Maki Nagasawa[1], Koenjong Lee[1], Toshiya Nakano[2], Shinya Kouketsu[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Meterolorogical Agency, 3.Japan Agency of Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AOS09-04] The deep Pacific meridional overturning circulation simulated by a low-resolution ocean model

★Invited Papers

*Takao Kawasaki[1], Hiroyasu Hasumi[1] (1.Atmosphere and Ocean Research Insitutute, the University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AOS09-05] The Role of Mixing and Geothermal Heating in Altering AABW and NADW Pathways

★Invited Papers

*Qianjiang Xing[1], Stephanie Downes[1], Kate Snow[2] (1.IMAS, Univ of Tasmania, AU, 2.School of GeoSciences, Univ of Edinburgh, UK)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 303 3F

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Jun Nishioka(Institute of low temperature science, Hokkaido University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AOS09-06] **Longterm changes in heat content, salinity and stratification over the Pacific Arctic and Subarctic continental shelves**

★Invited Papers

*Seth L Danielson[1] (1.University of Alaska Fairbanks)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AOS09-07] **Important roles of marginal seas and intermediate water for micro- and macro-nutrients circulation in the North Pacific**

*Jun Nishioka[1], Hajime Obata[2], Hiroshi Ogawa[2], Ichiro Yasuda[2] (1.Hokkaido University, Institute of low temperature sciences, 2.The University of Tokyo, Atmosphere and Ocean research institute)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AOS09-08] An insight into chemical speciation of dissolved iron in the intermediate water of the North Pacific

*Youhei Yamashita[1], Jun Nishioka[2], Hajime Obata[3], Hiroshi Ogawa[3] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Institute of Low Temperature Science, Hokkaido University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AOS09-09] Change in lower trophic level ecosystem and its complex mechanism in the North Pacific

★Invited Papers

Naomi Harada[1], Fujiki Tetsuichi[1], *Maki Noguchi Aita[1], Makio Honda[1], Minoru Kitamura[1], Takuhei Shiozaki[1], Yoshihisa Mino[3], Akira Kuwata[2], Kazuaki Tadokoro[2], Osamu Seki[4], Megumi Chikamoto[5] (1.Japan Agency for Marine-Earth Science and Technology, 2.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3.Institute for Space-Earth Environmental Research, Nagoya University, 4.Institute of Low Temperature Science, Hokkaido University, 5.International Pacific Research Center, University of Hawaii at Manoa)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AOS09-10] Numerical simulation of iron cycle in the North Pacific

*Kazuhiro Misumi[1], Jun Nishioka[2], Hajime Obata[3], Daisuke Tsumune[1], Tsubono Takaki[1], Matthew C Long[4], Keith Lindsay[4], J. Keith Moore[5] (1.Environmental Science Research Laboratory, Central Research Institute of Electric Power Industry, 2.Institute of Low Temperature Science, Hokkaido University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Climate and Global Dynamics Laboratory, National Center for Atmospheric Research, 5.Department of Earth System Science, University of California at Irvine)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AOS09-11] Influence of tide on the growth and migration of walleye pollock (*Gadus chalcogrammus*) in the Oyashio region

*Shin-ichi Ito[1], Zi-jian Wang[1], Hatsumi Nishikawa[3], Humio Mitsudera[3], Mitsuhiro Ishino[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Fisheries Research and Education Agency Japan, 3. Hokkaido University)

[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 303 3F

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Shin-Ichi Ito(The University of Tokyo)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AOS09-12] What can horizontal stirring tell us about vertical mixing?

★Invited Papers

*Sylvia T Cole[1] (1.Woods Hole Oceanographic Institution)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AOS09-13] Acoustic remote sensing of ocean mixing

★Invited Papers

*Tetjana Ross[1], Andone Lavery[2], Doris Leong[3], Rolf Lueck[4] (1.Institute Of Ocean Sciences, Fisheries and Oceans Canada, 2.Woods Hole Oceanographic Institution, 3.British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 4.Rockland Scientific International)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AOS09-14] Assessment of the effectiveness of the global ocean state estimation using tide-induced mixing parameterizations

*Satoshi Osafune[1], Shuhei Masuda[1], Nozomi Sugiura[1], Doi Toshimasa[1], Tadashi Hemmi[1] (1.JAMSTEC)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AOS09-15] **Energetics of Eddy-Mean Flow Interactions in Western Boundary Currents: The Kuroshio and the Gulf Stream**

★Invited Papers

*Enrique N Curchitser[1], Dujuan Kang[1], Xiaomei Yan[2] (1.Rutgers University New Brunswick, 2.Institute of Oceanology, Chinese Academy of Sciences)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AOS09-16] Mixing Processes in the Kuroshio region and their influence on the low-trophic ecosystem

★Invited Papers

*Xinyu Guo[1], Takeshi Matsuno[2], Tomoharu Senju [2], Kaoru Ichikawa[2], Takahiro Endoh[2], Eisuke Tsutsumi[2], Ayako Nishina[3], Hirohiko Nakamura[3], JING ZHANG[4], Daisuke Hasegawa[5], Naoki Yoshie[1], Toru Kobari[3] (1.Center for Marine Environmental Studies, Ehime University, 2.Research Institute for Applied Mechanics, Kyushu University,, 3.Faculty of Fisheries, Kagoshima University, 4.Graduate School of Science and Engineering, University of Toyama, 5.Tohoko National Fisheries Research Institute)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AOS09-17] Very strong turbulent mixing over 30-km and 200-m lateral and vertical scales in the Kuroshio near the continental slope in Hyuganada Sea

*Takeyoshi Nagai[1], Silvana Duran[2], Diego Otero[2], Yasutaka Mori[1], Naoki Yoshie[3], Kazuki Ohgi[3], Daisuke Hasegawa[4], Ayako Nishina[5], Toru Kobari[5] (1.Department of Ocean Sciences, Tokyo University of Marine Science and Technology, 2.Facultad de Pesquería, Universidad Nacional Agraria La Molina, Peru, 3.Center for Marine Environmental Studies, Ehime University, 4.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 5.Faculty of Fisheries Kagoshima University)

[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_7

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P01] Correction method of fast-response thermistors data to estimate turbulence intensity

*kimura shino[1], Yasutaka Goto[2], Koenjong Lee[1], Ichiro Yasuda[1] (1.The Univercity of Tokyo, 2.Meteorological Agency)

[AOS09-P02] Observation of turbulent mixing using a deep float with microstructure sensors

*Shuo Zhai[1], Ichiro Yasuda[1], Masaaki Kikuchi[1], Yasutaka Goto[1], Koenjong Lee[1], Takahiro Tanaka[2], Ken Yamaki[3], Yutaka Imamura[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Fisheries Research Agency, 3.TSK Tsurumi-Seiki Co., Ltd., 4.Aomori Prefectural Industrial Thechnology Research Center, Fisheries Research Insititute)

[AOS09-P03] Evaluation of the underwater glider flight model using the electromagnetic current sensor

*Takahiro Tanaka[1], Daisuke Hasegawa[1], Takeshi Okunishi[1], Ichiro Yasuda[2] (1.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 2.Atmosphere and Ocean Research Institute, University of Tokyo)

[AOS09-P04] Mixing processes observed by a slocum glider at the Oyashio-TWC front

*Daisuke Hasegawa[1], Takahiro Tanaka[1], Takeshi Okunishi[1], Ichiro Yasuda[2] (1.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P05] Impact of the astronomical lunar 18.6-yr tidal cycle on El-Niño and Southern Oscillation

*Ichiro Yasuda[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P06] The effect of 18.6-year period lunar nodal cycle on Pacific Decadal Oscillation (PDO)

*Masaki Hamamoto[1], Ichiro Yasuda[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P07] A comparison of ocean deoxygenation between CMIP5 models and an observational dataset

*Yumi Abe[1], Shoshiro Minobe[1,5], Takamitsu Ito[2], Curtis Deutsch[3], Matthew C. Long[4] (1.Department of Natural History Sciences, Graduate School of Science,Hokkaido University, Sapporo, Japan, 2.School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, Georgia, USA, 3.School of Oceanography, University of Washington, Seattle, Washington, USA, 4.Climate and Global Dynamics Laboratory, National Center for Atmospheric Research, Boulder, Colorado, USA, 5.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, Sapporo, Japan)

[AOS09-P08] Pacific Ocean State Estimation and Clarification of Mechanism of Ocean Circulation by Data Synthesis of Global Observations

*Shuhei Masuda[1] (1.Japan Agency for Marine-Earth Science and Technology)

[AOS09-P09] Impact of Tidal Vertical Mixing to Barotropic Water Exchange between the Sea of Okhotsk and Pacific through Diffusive Adjustment with Turbulent Closure Scheme

*Hung Wei Chou[1], Humio Mitsudera[1], Hatsumi Nishikawa[1], Kaihe Yamazaki[2] (1.Hokkaido University, Institute of Low Temperature Science, 2.Hokkaido University, Graduate School of Environmental Science)

[AOS09-P10] Distributions of organic Fe-binding ligands in the eastern and western subarctic North Pacific

*Yoshiko Kondo[1,2], Yudai Sunahara[2], Jun Nishioka[3], Hajime Obata[4], Shigenobu Takeda[1,2] (1.Graduate School of Fisheries and Environmental Sciences, Nagasaki University, 2.Faculty of Fisheries, Nagasaki University, 3.Institute of Low Temperature Science, Hokkaido University, 4.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P11] Chemical and physical speciation of copper in the subarctic North Pacific

*Kuo Hong Wong[1], Hajime Obata[1], Taejin Kim[2], Yoshiko Kondo[3], Jun Nishioka[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Seoul National University, Korea, 3.Nagasaki University, 4.Institute of Low

Temperature Science, Hokkaido University)

[AOS09-P12] Latitudinal and temporal variations in phytoplankton size structure within mesoscale eddies from space

*Hisatomo Waga[1], Toru Hirawake[1], Ueno Hiromichi[1] (1.Hokkaido University)

[AOS09-P13] Structure and impact of the Kuroshio nutrient stream

*Kosei Komatsu[1,2], Yutaka Hiroe[3] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Japan, 3.Seikai National Fisheries Research Institute, Japan Fisheries Research and Education Agency, Nagasaki, Japan)

[AOS09-P14] Enhanced nutrient supply and biogeochemical impacts induced by internal waves in the oligotrophic northern South China Sea

*Chin-chang Hung[1], Dewang Li[2], Wen-Chen Chou[3], Yung-Yen Shih[1,4], Guan-Yu Chen[1] (1.Department of Oceanography, National Sun Yat Sen University, Kaohsiung, Taiwan, 2.Second Institute of Oceanography, State Oceanic Administration, Hangzhou, PRC, 3.Institute of Marine Environmental Chemistry and Ecology, National Taiwan Ocean University, Taiwan, 4.Department of Applied Science, R.O.C Naval Academy, Kaohsiung, Taiwan)

[AOS09-P15] Mixing over the eastern ridge in the Luzon Strait caused by high-mode internal waves

*Akie Sakai[1], Tomoharu Senjyu[2], Eisuke Tsutsumi[2], Takeshi Matsuno[2], Takahiro Endo[2], Ichiro Yasuda[3], Daigo Yanagimoto[3] (1.Department of Earth System Science and Technology, Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, 2.Research Institute for Applied Mechanics , 3.Atmosphere and Ocean Reserch Institute The University of Tokyo)

[AOS09-P16] **From the Luzon Strait to the Tsushima Strait: Water masses and nutrient transports approached using ^{137}Cs**

*Siteng Zhu[1], JING ZHANG[1], Shota Kambayashi[2], Takeshi Matsuno[3], Eisuke Tsutsumi[3], Shigenobu Takeda[4], Seiya Nagao[5], Hiroshi Inoue[5], Hiroshi Ogawa[6], Ichiro Yasuda[6] (1.University of Toyama, 2.Fukushima university, 3.Kyushu university, 4.Nagasaki university, 5.Kanazawa university, 6.The University of Tokyo)

[AOS09-P17] Impact of cyclonic eddies and typhoons on biogeochemistry in the oligotrophic ocean based on time-series observation at the western Pacific subtropical station KEO

*Makio Honda[1], Yoshikazu Sasai[1], Eko Siswanto[1], Akira Kuwano-Yoshida[2], Hidenori AIKI[3], Meghan Cronin[4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Disaster Prevention Laboratory, Kyoto University, 3.Nagoya University, 4.NOAA Pacific Marine Environmental Laboratory)

[AOS09-P18] Island-mass effect on the phytoplankton and zooplankton community in south of Japan

*Kiyotaka Hidaka[1], Kazuaki Tadokoro[1], Hiroomi Miyamoto[1], Tadafumi Ichikawa[1] (1.Japan Fisheries Research and Education Agency)

[AOS09-P19] Influence of enhanced deep circulation due to geothermal heat on biogeochemical cycle in the Pacific Ocean

*Shogo Urakawa[1], Hideyuki Nakano[1], Hiroyuki Tsujino[1], Kei Sakamoto[1], Takahiro Toyoda[1], Goro Yamanaka[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

[AOS09-P20] The Parameterization of the Pressure-Strain Correlations in the Stably or Unstably Stratified Ocean Surface Layer.

*Yusuke Ushijima[1], Yutaka Yoshikawa[1] (1.Graduate School of Science, Kyoto University)

[AOS09-P21] Numerical studies on asymmetric responses of the upper ocean to tropical cyclone

*Daiki Okura[1], Yutaka Yoshikawa[1] (1.Graduate School of Science, Kyoto University)

[AOS09-P22] Influence of the distortion of the internal wave field on estimates of turbulent mixing using fine-scale parameterizations

*Anne Takahashi[1], Toshiyuki Hibiya[1], Alberto C. Naveira Garabato[2] (1.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2.National Oceanography Centre, University of Southampton)

[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_11

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P01] Correction method of fast-response thermistors data to estimate turbulence intensity

*kimura shino[1], Yasutaka Goto[2], Koenjong Lee[1], Ichiro Yasuda[1] (1.The Univercity of Tokyo, 2.Meteorological Agency)

[AOS09-P02] Observation of turbulent mixing using a deep float with microstructure sensors

*Shuo Zhai[1], Ichiro Yasuda[1], Masaaki Kikuchi[1], Yasutaka Goto[1], Koenjong Lee[1], Takahiro Tanaka[2], Ken Yamaki[3], Yutaka Imamura[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Fisheries Research Agency, 3.TSK Tsurumi-Seiki Co., Ltd., 4.Aomori Prefectural Industrial Thechnology Research Center, Fisheries Research Insititute)

[AOS09-P03] Evaluation of the underwater glider flight model using the electromagnetic current sensor

*Takahiro Tanaka[1], Daisuke Hasegawa[1], Takeshi Okunishi[1], Ichiro Yasuda[2] (1.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 2.Atmosphere and Ocean Research Institute, University of Tokyo)

[AOS09-P04] Mixing processes observed by a slocum glider at the Oyashio-TWC front

*Daisuke Hasegawa[1], Takahiro Tanaka[1], Takeshi Okunishi[1], Ichiro Yasuda[2] (1.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P05] Impact of the astronomical lunar 18.6-yr tidal cycle on El-Niño and Southern Oscillation

*Ichiro Yasuda[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P06] The effect of 18.6-year period lunar nodal cycle on Pacific Decadal Oscillation (PDO)

*Masaki Hamamoto[1], Ichiro Yasuda[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P07] A comparison of ocean deoxygenation between CMIP5 models and an observational dataset

*Yumi Abe[1], Shoshiro Minobe[1,5], Takamitsu Ito[2], Curtis Deutsch[3], Matthew C. Long[4] (1.Department of Natural History Sciences, Graduate School of Science,Hokkaido University, Sapporo, Japan, 2.School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, Georgia, USA, 3.School of Oceanography, University of Washington, Seattle, Washington, USA, 4.Climate and Global Dynamics Laboratory, National Center for Atmospheric Research, Boulder, Colorado, USA, 5.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, Sapporo, Japan)

[AOS09-P08] Pacific Ocean State Estimation and Clarification of Mechanism of Ocean Circulation by Data Synthesis of Global Observations

*Shuhei Masuda[1] (1.Japan Agency for Marine-Earth Science and Technology)

[AOS09-P09] Impact of Tidal Vertical Mixing to Barotropic Water Exchange between the Sea of Okhotsk and Pacific through Diffusive Adjustment with Turbulent Closure Scheme

*Hung Wei Chou[1], Humio Mitsudera[1], Hatsumi Nishikawa[1], Kaihe Yamazaki[2] (1.Hokkaido University, Institute of Low Temperature Science, 2.Hokkaido University, Graduate School of Environmental Science)

[AOS09-P10] Distributions of organic Fe-binding ligands in the eastern and western subarctic North Pacific

*Yoshiko Kondo[1,2], Yudai Sunahara[2], Jun Nishioka[3], Hajime Obata[4], Shigenobu Takeda[1,2] (1.Graduate School of Fisheries and Environmental Sciences, Nagasaki University, 2.Faculty of Fisheries, Nagasaki University, 3.Institute of Low Temperature Science, Hokkaido University, 4.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P11] Chemical and physical speciation of copper in the subarctic North Pacific

*Kuo Hong Wong[1], Hajime Obata[1], Taejin Kim[2], Yoshiko Kondo[3], Jun Nishioka[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Seoul National University, Korea, 3.Nagasaki University, 4.Institute of Low

Temperature Science, Hokkaido University)

[AOS09-P12] Latitudinal and temporal variations in phytoplankton size structure within mesoscale eddies from space

*Hisatomo Waga[1], Toru Hirawake[1], Ueno Hiromichi[1] (1.Hokkaido University)

[AOS09-P13] Structure and impact of the Kuroshio nutrient stream

*Kosei Komatsu[1,2], Yutaka Hiroe[3] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Japan, 3.Seikai National Fisheries Research Institute, Japan Fisheries Research and Education Agency, Nagasaki, Japan)

[AOS09-P14] Enhanced nutrient supply and biogeochemical impacts induced by internal waves in the oligotrophic northern South China Sea

*Chin-chang Hung[1], Dewang Li[2], Wen-Chen Chou[3], Yung-Yen Shih[1,4], Guan-Yu Chen[1] (1.Department of Oceanography, National Sun Yat Sen University, Kaohsiung, Taiwan, 2.Second Institute of Oceanography, State Oceanic Administration, Hangzhou, PRC, 3.Institute of Marine Environmental Chemistry and Ecology, National Taiwan Ocean University, Taiwan, 4.Department of Applied Science, R.O.C Naval Academy, Kaohsiung, Taiwan)

[AOS09-P15] Mixing over the eastern ridge in the Luzon Strait caused by high-mode internal waves

*Akie Sakai[1], Tomoharu Senjyu[2], Eisuke Tsutsumi[2], Takeshi Matsuno[2], Takahiro Endo[2], Ichiro Yasuda[3], Daigo Yanagimoto[3] (1.Department of Earth System Science and Technology, Interdisciplinary Graduate School of Engineering Sciences, Kyushu University, 2.Research Institute for Applied Mechanics , 3.Atmosphere and Ocean Reserch Institute The University of Tokyo)

[AOS09-P16] **From the Luzon Strait to the Tsushima Strait: Water masses and nutrient transports approached using ^{137}Cs**

*Siteng Zhu[1], JING ZHANG[1], Shota Kambayashi[2], Takeshi Matsuno[3], Eisuke Tsutsumi[3], Shigenobu Takeda[4], Seiya Nagao[5], Hiroshi Inoue[5], Hiroshi Ogawa[6], Ichiro Yasuda[6] (1.University of Toyama, 2.Fukushima university, 3.Kyushu university, 4.Nagasaki university, 5.Kanazawa university, 6.The University of Tokyo)

[AOS09-P17] Impact of cyclonic eddies and typhoons on biogeochemistry in the oligotrophic ocean based on time-series observation at the western Pacific subtropical station KEO

*Makio Honda[1], Yoshikazu Sasai[1], Eko Siswanto[1], Akira Kuwano-Yoshida[2], Hidenori AIKI[3], Meghan Cronin[4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Disaster Prevention Laboratory, Kyoto University, 3.Nagoya University, 4.NOAA Pacific Marine Environmental Laboratory)

[AOS09-P18] Island-mass effect on the phytoplankton and zooplankton community in south of Japan

*Kiyotaka Hidaka[1], Kazuaki Tadokoro[1], Hiroomi Miyamoto[1], Tadafumi Ichikawa[1] (1.Japan Fisheries Research and Education Agency)

[AOS09-P19] Influence of enhanced deep circulation due to geothermal heat on biogeochemical cycle in the Pacific Ocean

*Shogo Urakawa[1], Hideyuki Nakano[1], Hiroyuki Tsujino[1], Kei Sakamoto[1], Takahiro Toyoda[1], Goro Yamanaka[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

[AOS09-P20] The Parameterization of the Pressure-Strain Correlations in the Stably or Unstably Stratified Ocean Surface Layer.

*Yusuke Ushijima[1], Yutaka Yoshikawa[1] (1.Graduate School of Science, Kyoto University)

[AOS09-P21] Numerical studies on asymmetric responses of the upper ocean to tropical cyclone

*Daiki Okura[1], Yutaka Yoshikawa[1] (1.Graduate School of Science, Kyoto University)

[AOS09-P22] Influence of the distortion of the internal wave field on estimates of turbulent mixing using fine-scale parameterizations

*Anne Takahashi[1], Toshiyuki Hibiya[1], Alberto C. Naveira Garabato[2] (1.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2.National Oceanography Centre, University of Southampton)

[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_3

[A-OS21] Physical, biogeochemical, and ecological aspects and their mutual relations in the Indian Ocean

convener:Yukio Masumoto(Graduate School of Science, The University of Tokyo), Hiroaki Saito(Atmosphere and Ocean Research Institute, The University of Tokyo), Iwao Ueki(JAMSTEC Japan Agency for Marine-Earth Science and Technology)

[AOS21-P01] **Freshening of Indonesian Upper Water and Salinification of Indonesian Intermediate Water in the Indian Ocean during the last decade**

*ISKANDAR MOCHAMAD RIZA[1], Toshio Suga[1] (1.Graduate School of Sciences, Tohoku University)

[AOS21-P02] Characteristics in the upper ocean physical properties associated with 2018 Ningaloo Nina observed during R/V Hakuho-Maru KH-18-6 cruise

*Yukio Masumoto[1], Iwao Ueki[2], Kentaro Ando[2], Takanori Horii[2], Motoki Nagura[2], Shuhei Matsugishi[1], Shoichiro Kido[1], Takuro Matsuta[1] (1.Graduate School of Science, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_12

[A-OS21] Physical, biogeochemical, and ecological aspects and their mutual relations in the Indian Ocean

convener:Yukio Masumoto(Graduate School of Science, The University of Tokyo), Hiroaki Saito(Atmosphere and Ocean Research Institute, The University of Tokyo), Iwao Ueki(JAMSTEC Japan Agency for Marine-Earth Science and Technology)

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*Yukio Masumoto[1], Iwao Ueki[2], Kentaro Ando[2], Takanori Horii[2], Motoki Nagura[2], Shuhei Matsugishi[1], Shoichiro Kido[1], Takuro Matsuta[1] (1.Graduate School of Science, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 303 3F

[A-OS21] Physical, biogeochemical, and ecological aspects and their mutual relations in the Indian Ocean

convener:Yukio Masumoto(Graduate School of Science, The University of Tokyo), Hiroaki Saito(Atmosphere and Ocean Research Institute, The University of Tokyo), Iwao Ueki(JAMSTEC Japan Agency for Marine-Earth Science and Technology), Chairperson:Yukio Masumoto

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AOS21-01] Coastal upwelling events and barrier layer observed along the southwestern coast of Sumatra

*Takanori Horii[1], Iwao Ueki[1], Kentaro Ando[1] (1.Research and Development Center for Global Change (RCGC), Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AOS21-02] Mechanisms of the sea surface temperature cooling in the Somalia-Oman upwelling region during the summer monsoon

*Kusumi Takahiro[1], Shoichiro Kido[1], Tomoki Tozuka[1], Yukio Masumoto[1] (1.the Unversity of Tokyo)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AOS21-03] Generation of meso-scale eddies in the southern Indian ocean

*Takuro Matsuta[1], Yukio Masumoto[1] (1.Graduate School of Science, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AOS21-04] Summary of R/V Hakuho-Maru observations (KH-18-6) for Integrated physical, biogeochemical, and ecosystem research in the eastern Indian Ocean

*Yukio Masumoto[1], Hiroaki Saito[2] (1.Graduate School of Science, The University of Tokyo, 2.Atmosphere and Ocean Research Institute)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AOS21-05] Distribution and photodegradation of fluorescent dissolved organic matter in the eastern Indian Ocean

*Shigenobu Takeda[1] (1.Nagasaki University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AOS21-06] Observed subsurface Chlorophyll maximum in the tropical eastern Indian Ocean during KH18-6 Leg3 cruise

*Iwao Ueki[1], Kosei Sasaoka[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 301A 3F

[A-CG43] Adaptation for climate change and social implementation

convener:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience), Chairperson:KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience), Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACG43-01] **Effects of afforestation and climate warming on evapotranspiration and river discharge in the upper Chao Phraya River basin**

*Kumiko TAKATA[1], Naota Hanasaki[1] (1.National Institute for Environmental Studies)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACG43-02] Hybrid downscaling using high-resolution RCM information and rainfall-runoff-inundation model simulations

*Yasutaka Wakazuki[1,2], Shiori Abe[4], Yosuke Nakamura[3,4] (1.Ibaraki University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Public Works Research Institute, 4.Mitsui Consultants Co., Ltd.)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACG43-03] Development of a global water risk assessment tool to support investigation of adaptation to climate change in the private sector: Calibrating parameters of a global water resources model by Approximate Bayesian Computation

*Naota Hanasaki[1] (1.NIES National Institute of Environmental Studies)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACG43-04] Verification of SI-CAT ocean products around Japan

*Goro Yamanaka[1], Hideyuki Nakano[1], Kei Sakamoto[1], Takahiro Toyoda[1], Shogo Urakawa[1], Hiroyuki Tsujino[1], Shiro Nishikawa[2], Tsuyoshi Wakamatsu[2,3,4], Yoichi Ishikawa[2] (1.Meteorological Research Institute, 2.JAMSTEC, 3.Nansen Environmental and Remote Sensing Center, 4.Bjerknes Centre for Climate Research)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACG43-05] Downscaling and Reanalysis of Coastal Current System on the Ibaraki Coast with Included Freshwater Impact

*Josko Troselj[1], Yuki Imai[2], Junichi Ninomiya[3], Nobuhito Mori[1] (1.Coastal Engineering Laboratory, Disaster Prevention Research Institute, Kyoto University, 2.Graduate School of Engineering, Kyoto University, 3.Kanazawa University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACG43-06] Estimation of the Japanese sardine stock in relation to the future Kuroshio variability

*Haruka Nishikawa[1], Shiro Nishikawa[1], Tsuyoshi Wakamatsu[2,3], Yoichi Ishikawa[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Nansen Environmental and Remote Sensing Center, 3.Bjerknes Center for Climate Research)

[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_4

[A-CG43] Adaptation for climate change and social implementation

convener:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience)

[ACG43-P01] Impact of urbanization on the surface air temperature across Bulgaria

*Lidia Lazarova Vitanova[1], Hiroyuki Kusaka[2] (1.Graduate School of Life and Environmental Sciences, the University of Tsukuba, 2.Center for Computational Sciences, the University of Tsukuba)

[ACG43-P02] Clear-air Turbulence over the North Pacific under 2-K Global Warming – Ensemble Projections using a 60-km Atmospheric General Circulation Model

*Shingo Watanabe[1], Mikiko Fujita[1], Sho Kawazoe[1], Shiori Sugimoto[1], Yasuko Okada[1], Ryo Mizuta[2], Masayoshi Ishii[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meteorological Research Institute, Japan Meteorological Agency)

[ACG43-P03] Projections of future beach loss in Japan and uncertainties in projected beach loss

*Keiko Udo[1], Yuriko Takeda[1] (1.International Research Institute of Disaster Science, Tohoku University)

[ACG43-P04] Future projection of forest fire frequency due to climate change in Japan by using predicted relative humidity and wind speed

*Yoshiyuki Yokoo[1], Ren Iwasaki[1] (1.Fukushima University)

[ACG43-P05] Coastal preservation and use of ocean and coastal climate prediction

*Satoshi Takewaka[1] (1.University of Tsukuba)

[ACG43-P06] **Present and Future Potential Distribution of Hill Glory Bower (*Clerodendrum infortunatum* Linn.) using Maximum Entropy Modeling in Doon Valley, Uttarakhand, India.**

*Saurabh Purohit[1,3], Neelam Rawat[2] (1.Indian Institute of Remote Sensing, Dehradun, India, 2.Uttarakhand Space Application Centre, Dehradun, India, 3.Forest Research Institute Deemed University, Dehradun, India)

[ACG43-P07] Development of high-resolution ocean future projection dataset around Japan using CMIP5 atmospheric forcing

*Shiro Nishikawa[1], Tsuyoshi Wakamatsu[2], Yoichi Ishikawa[1], Hiroshi Ishizaki[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology, 2.Nansen Environmental and Remote Sensing Center/Bjerknes Center for Climate Research)

[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_13

[A-CG43] Adaptation for climate change and social implementation

convener:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience)

[ACG43-P01] Impact of urbanization on the surface air temperature across Bulgaria

*Lidia Lazarova Vitanova[1], Hiroyuki Kusaka[2] (1.Graduate School of Life and Environmental Sciences, the University of Tsukuba, 2.Center for Computational Sciences, the University of Tsukuba)

[ACG43-P02] Clear-air Turbulence over the North Pacific under 2-K Global Warming – Ensemble Projections using a 60-km Atmospheric General Circulation Model

*Shingo Watanabe[1], Mikiko Fujita[1], Sho Kawazoe[1], Shiori Sugimoto[1], Yasuko Okada[1], Ryo Mizuta[2], Masayoshi Ishii[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meteorological Research Institute, Japan Meteorological Agency)

[ACG43-P03] Projections of future beach loss in Japan and uncertainties in projected beach loss

*Keiko Udo[1], Yuriko Takeda[1] (1.International Research Institute of Disaster Science, Tohoku University)

[ACG43-P04] Future projection of forest fire frequency due to climate change in Japan by using predicted relative humidity and wind speed

*Yoshiyuki Yokoo[1], Ren Iwasaki[1] (1.Fukushima University)

[ACG43-P05] Coastal preservation and use of ocean and coastal climate prediction

*Satoshi Takewaka[1] (1.University of Tsukuba)

[ACG43-P06] **Present and Future Potential Distribution of Hill Glory Bower (*Clerodendrum infortunatum* Linn.) using Maximum Entropy Modeling in Doon Valley, Uttarakhand, India.**

*Saurabh Purohit[1,3], Neelam Rawat[2] (1.Indian Institute of Remote Sensing, Dehradun, India, 2.Uttarakhand Space Application Centre, Dehradun, India, 3.Forest Research Institute Deemed University, Dehradun, India)

[ACG43-P07] Development of high-resolution ocean future projection dataset around Japan using CMIP5 atmospheric forcing

*Shiro Nishikawa[1], Tsuyoshi Wakamatsu[2], Yoichi Ishikawa[1], Hiroshi Ishizaki[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology, 2.Nansen Environmental and Remote Sensing Center/Bjerknes Center for Climate Research)

[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 301A 3F

[A-CG43] Adaptation for climate change and social implementation

convener:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG43-07] Recent progress of Japan's regional downscaling project (SI-CAT) and CORDEX Asia Empirical-Statistical Downscaling (ESD)

*KOJI DAIRAKU[1] (1.National Research Institute for Earth Science and Disaster Resilience)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG43-08] Assessment of Flood Risk in Hokkaido, northern Japan, Associated with Climate Change

*Hoshino Tsuyoshi[1], Tomohito J Yamada[1], Dzung Nguyen-Le[1], Masaru Inatsu[1], Tomonori Satou[1], Hiroaki Kawase[2] (1.Hokkaido University, 2.Meteorological Research Institute)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[ACG43-09] Intensification of sub-daily and daily rainfall extremes from densely distributed records for Japan

*Megumi Watanabe[1], Sayaka Yoshikawa[1], Shinjiro Kanae[1] (1.Tokyo Institute of Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[ACG43-10] A Content-Based Database System for Large Ensemble Future Climate Simulations

*Yujin Nakagawa[1], Shintaro Kawahara[1], Fumiaki Araki[1], Daisuke Matsuoka[1], Yoichi Ishikawa[1], Mikiko Fujita[1], Shiori Sugimoto[1], Yasuko Okada[1], Sho Kawazoe[1], Shingo Watanabe[1], Masayoshi Ishii[2], Ryo Mizuta[2], Akihiko Murata[2], Hiroaki Kawase[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meteorological Research Institute)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[ACG43-11] Climate change impact assessment in Shikoku with the ensemble climate prediction database d4PDF

*kouhei yoshimura[1], Nasu Seigo[1], Patricia Sanchez[2] (1.Kochi University of Technology, 2.University of the Philippines Los Baños)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[ACG43-12] Caution zone quantification risk to sediment disaster adaptation due to climate change

*SEIKI KAWAGOE[1], YOSUKE SAITO[1], HIROMICHI SUZUKI[1] (1.Fukushima university)

[E] Oral | H (Human Geosciences)：H-GG Geography

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 106 1F

[H-GG01] Human-Natural system interactions and solutions for environmental management

convener:Yuei-An Liou(National Central University), Chairperson:Yuei-An Liou(Center for Space and Remote Sensing Research (CSRSR)), Kim-Anh Nguyen(National Central University)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HGG01-01] Monitoring of Subsidence Area of Jakarta City using PS-InSAR

*Josaphat Tetuko Sri Sumantyo[1] (1.Center for Environmental Remote Sensing, Chiba University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HGG01-02] **Understanding and classifying spatial patterns of global eco-environmental vulnerability**

*Kim-Anh Nguyen[1], Yuei-An Liou[1] (1.National Central University, Taiwan)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HGG01-03] Human-water interface in hydrological modeling: Current status and future directions

*Yoshihide Wada[1] (1.International Institute for Applied Systems Analysis)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HGG01-04] **Urban greenspace spatial patterns and eco-function by using Sentinel 2 imagery**

*Yuei-An Liou[1], Kim-Anh Nguyen[1] (1.National Central University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HGG01-05] Assessing performance of L-band SAR backscatter for above ground forest biomass estimation over complex topography

*Waqar Mirza Muhammad[1], Ji Yaqi[1], Josaphat Tetuko Sri Sumantyo[1], Hasil Khan[1] (1.Chiba University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HGG01-06] **Feasibility Analysis of Engineering Monitoring Using the VLP-16 LiDAR Puck: A Case Study in Henglingshan Tunnel**

*Zhen-Yu Wu[1], Shen Yu Hsiao[1], Yan-Jyun Lin[1], Ren-Jhih Yang[1] (1.National Chung Hsing University)

[E] Poster | H (Human Geosciences)：H-GG Geography

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_8

[H-GG01] Human-Natural system interactions and solutions for environmental management

convener:Yuei-An Liou(National Central University)

[HGG01-P01] **Feasibility assessment of constructing high-resolution 3D panoramic images using the VLP-16 LiDAR Puck**

*Yan-Jyun Lin[1], Shen Yu Hsiao[1], REN-JHIH YANG[1], Zhen-Yu Wu[1] (1.National Chung Hsing University)

[HGG01-P02] **The environmental impact of mountaineering in the Mt. Manaslu region**

*Hijiri SHIMOJIMA[1] (1.Tokyo University of Agriculture)

[HGG01-P03] Understanding human system vulnerability to typhoon for Improved Adaptive Capacity

*Kim-Anh Nguyen[1], Yuei-An Liou[1] (1.Center for Space and Remote Sensing Research, National Central University)

[HGG01-P04] Environmental Impact Evaluation of Solar Park Project in Western Desert, Minia, Egypt.

*Ramadan Gamal Abdelrehim[1], Josaphat Tetuko Sri Sumantyo[1] (1.Center for Environmental Remote Sensing, Chiba University)

[HGG01-P05] Peatland Assessment Based on DInSAR approach by using ALOS-2 PALSAR-2 Data in Kalimantan, Indonesia

*Joko Widodo[1], Josaphat Tetuko Sri Sumantyo[1], Daniele Perissin[2], Katsunoshin Nishi[1], Pakhrur Rozi[1] (1.JMRSL - Josaphat Microwave Remote Sensing Laboratory Center for Environmental Remote Sensing Graduate School of Advanced Integration Science Chiba University, 2.Sarproz, Razer Limited, Hongkong)

[HGG01-P06] Development of Nanosatellite for Ionospheric Measurement for Earthquake Prediction

*Peberlin Parulian Sitompul[1], Josaphat Tetuko Sri Sumantyo[2] (1.Chiba University, and Indonesia National Institute of Aeronautic and Space, 2.Center for Environmental Remote Sensing, Chiba University)

[E] Poster | H (Human Geosciences)：H-GG Geography

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_14

[H-GG01] Human-Natural system interactions and solutions for environmental management

convener:Yuei-An Liou(National Central University)

[HGG01-P01] **Feasibility assessment of constructing high-resolution 3D panoramic images using the VLP-16 LiDAR Puck**

*Yan-Jyun Lin[1], Shen Yu Hsiao[1], REN-JHIH YANG[1], Zhen-Yu Wu[1] (1.National Chung Hsing University)

[HGG01-P02] **The environmental impact of mountaineering in the Mt. Manaslu region**

*Hijiri SHIMOJIMA[1] (1.Tokyo University of Agriculture)

[HGG01-P03] Understanding human system vulnerability to typhoon for Improved Adaptive Capacity

*Kim-Anh Nguyen[1], Yuei-An Liou[1] (1.Center for Space and Remote Sensing Research, National Central University)

[HGG01-P04] Environmental Impact Evaluation of Solar Park Project in Western Desert, Minia, Egypt.

*Ramadan Gamal Abdelrehim[1], Josaphat Tetuko Sri Sumantyo[1] (1.Center for Environmental Remote Sensing, Chiba University)

[HGG01-P05] Peatland Assessment Based on DInSAR approach by using ALOS-2 PALSAR-2 Data in Kalimantan, Indonesia

*Joko Widodo[1], Josaphat Tetuko Sri Sumantyo[1], Daniele Perissin[2], Katsunoshin Nishi[1], Pakhrur Rozi[1] (1.JMRSL - Josaphat Microwave Remote Sensing Laboratory Center for Environmental Remote Sensing Graduate School of Advanced Integration Science Chiba University, 2.Sarproz, Razer Limited, Hongkong)

[HGG01-P06] Development of Nanosatellite for Ionospheric Measurement for Earthquake Prediction

*Peberlin Parulian Sitompul[1], Josaphat Tetuko Sri Sumantyo[2] (1.Chiba University, and Indonesia National Institute of Aeronautic and Space, 2.Center for Environmental Remote Sensing, Chiba University)

[J] Oral | H (Human Geosciences)：H-GG Geography

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 102 1F

[H-GG02] Use, change, management of natural resources and environment: Interdisciplinary perspectives

convener:Yoshinori OTSUKI(Institute of Geography, Graduate School of Science, Tohoku University), Gen Ueda(Graduate School of Social Sciences, Hitotsubashi University), Takahisa Furuichi(Graduate School of Science, Hokkaido University), Toru Sasaki(Miyagi University of Education), Chairperson:Yoshinori OTSUKI, Gen UEDA

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HGG02-01] Source identification of pottery based on chemical analysis of volcanic glass contained in ceramic paste
- Example for Usultan pottery in Chalchuapa, El Salvador, Central America -

*Shigeru Kitamura[1], Masakage Murano[2] (1.Faculty of Social Welfare, Hirosaki Gakuin University, 2.The Museum of Kyoto)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HGG02-02] Preliminary magnetic biomonitoring study of the spatial distribution of roadside pollution using *Cryptomeria japonica* tree bark

*Nagisa Sawada[1], Kazuo Kawasaki[1] (1.University of toyama)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HGG02-03] Preliminary environmental magnetic results from heavy metal contamination around the Erdenet Cu-Mo deposit, Mongolia.

*Kazuo Kawasaki[1], Ryuki Tonami[2], Solongo Tsetsgee[3], Baasansuren Gankhurel[3], Keisuke Fukushi[4] (1.Graduate School of Science and Engineering for Research, University of Toyama, 2.Department of Earth Sciences, University of Toyama, 3.Kanazawa University, 4.Institute of nature & Environmental Technology, Kanazawa University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HGG02-04] Sediment and its movement as natural resources and environment

*Takahisa Furuichi[1], Sachi Wakasa[2], Shigeru Mizugaki[3], Masanori Nunokawa[3] (1.Graduate School of Agriculture, Hokkaido University, 2.Graduate School of International Resource Sciences, Akita University, 3.Civil Engineering Research Institute for Cold Region)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HGG02-05] Reutilization of waste bamboo from oyster farming

*KIYOSHI SAIJO[1] (1.Miyagi University of Education)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HGG02-06] Regional Impacts of Globally Important Agricultural Heritage Systems in Osaki City, Miyagi Prefecture

*Toru Sasaki[1] (1.Miyagi University of Education)

[J] Poster | H (Human Geosciences)：H-GG Geography

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_15

[H-GG02] Use, change, management of natural resources and environment: Interdisciplinary perspectives

convener:Yoshinori OTSUKI(Institute of Geography, Graduate School of Science, Tohoku University), Gen Ueda(Graduate School of Social Sciences, Hitotsubashi University), Takahisa Furuichi(Graduate School of Science, Hokkaido University), Toru Sasaki(Miyagi University of Education)

[HGG02-P01] Preliminary magnetic biomonitoring results of the spatial distribution of atmospheric particulate matter in Muroran, Japan

*Hiroki Shibata[1], Kazuo Kawasaki[1] (1.University of Toyama)

[HGG02-P02] Social Foundations of Entomophagy and Its Transformation: A Case Study of Ina City, Nagano Prefecture

*Naoki Kobayashi[1] (1.National University Corporation Kanazawa University)

[HGG02-P03] Cost sharing and free water policy in semi-arid rural Kenya

*Gen Ueda[1] (1.Graduate School of Social Sciences, Hitotsubashi University)

[HGG02-P04] Importance of the stories as the background of nature understanding: an example in the Visayas, the Philippines

*Takashi Ito[1] (1.Faculty of Education, Ibaraki University)

[HGG02-P05] Hydrogeomorphological and environmental geographical land condition of groundwater use areas along the coast of Lake Victoria, west Kenya

*Yoshinori OTSUKI[1] (1.Institute of Geography, Graduate School of Science, Tohoku University)

[J] Oral | H (Human Geosciences)：H-QR Quaternary research

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 102 1F

[H-QR05] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Masayuki Hyodo(Research Center for Inland Seas, Kobe University), Chairperson:Ken Ikehara(AIST), Kaori Aoki

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HQR05-01] Disturbance of sea floor by large earthquake and formation of earthquake-induced event deposit: Where is a suitable location for deep-sea turbidite paleoseismology

★Invited Papers

*Ken Ikehara[1] (1.Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HQR05-02] The Diatom Assemblages as the Indicators for Huge Tsunami Sedimentations and Recover Processes of Environment at Kesennuma Bay, Tohoku, Japan

*Kaoru Kashima[1], Ryozo Shiomi, Yu Fukumoto[3], Tsuyoshi Haraguchi[2] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Department of Geosicneces, Graduate School of Science, Osaka City University, 3.Ritsumeikan University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HQR05-03] **Niger Delta dynamic phase in the Gulf of Guinea during the last 20 ka: Panacea for the sustainable development of the region**

*Onema Christopher Adojoh[1], Marret-Davies Fabienne[2], Tetsuji Muto[3] (1.Missouri Univetrsity of Science and Technology, Rolla, USA, Dept of Geoscience, Geological and Petroleum Engineering, 1400 North Bishop, Post Code 65401, 2.School of Environmental Sciences, University of Liverpool, L69 7ZT, UK, 3.Nagasaki University, Japan, Dept of Environmental Science and Fisheries, 1-14 Bunkyomachi, Nagasaki, 8528521)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HQR05-04] K-feldspar post-IR IRSL ages suggest the presence of MIS 5a–c marine terraces in the eastern margin of the Kanto Plain, central Japan

★Invited Papers

*Toru Tamura[1,2], Hiroko Okazaki[3], Hiroomi Nakazato[4], Tomonori Naya[1], Rei Nakashima[1] (1.Geological Survey of Japan, AIST, 2.Graduate School of Frontier Sciences, University of Tokyo, 3.Natural History Museum and Institute, Chiba, 4.National Agriculture and Food Research Organization)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HQR05-05] Tephrostratigraphy of drilled core C9010E off the Boso Peninsula: as a preliminary report

*Kaori Aoki[1], Makoto Kobayashi[1], Masanori Murata[1], Takehiko Suzuki[1] (1.Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HQR05-06] Late Quaternary fluvial terraces and piracies in the Tanagura area, along the upper reaches of Kuji River, NE Japan

*Yuichi Kato[1], Takehiko Suzuki[1] (1.Graduate school of Urvan Environmental Sciences, Tokyo Metropolitan University)

[J] Oral | H (Human Geosciences)：H-QR Quaternary research

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 102 1F

[H-QR05] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Masayuki Hyodo(Research Center for Inland Seas, Kobe University), Chairperson:Mamoru KOARAI(Ibaraki University), Tomonori Naya(産業技術総合研究所)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[HQR05-07] Landform features of Okinoshima of Munakata city

*Takahito Kuroki[1] (1.Faculty of Education, Univ. of Teacher Edu. Fukuoka)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[HQR05-08] Revision of geomorphology and geology of Tokyo Upland and Lowland, based on boring data and precise landform analysis

★Invited Papers

*Kunihiko Endo[1], Yusuke Suginaka[2], Shinzaburo Hori[2], Toshihiko Sugai[3], Takehiko Suzuki[4], Shigeko Ishiwata, Yo Uesugi, Reisuke Kondo[5], Tatsuro Chiba[6], Toshio Nakayama[7], Shigeto Osato[8], Marie Noguchi[9], Akio Sato[3], Takato Takemura[10] (1.Nihon University, 2.Research Center of Computational Mechanics, Inc., 3.Graduate School of Frontier Science, The University of Tokyo, 4.Faculty of Urban Environmental Sciences, Tokyo Metropolitan University, 5.Educational Development Center, Kogakkan University, 6.Asia Air Survey, 7.Civil Engineering Support & Training Center, Tokyo Metropolitan Government,, 8.Doshitsu Research Corporation, 9.Paleo Labo co.,ltd., 10.College of Humanities and Sciences, Nihon University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HQR05-09] Sedimentological characteristics of the Ome Formation exposed on the western margin of Musasino Upland, central Japan

*Takako UTSUGAWA[1], Masaaki Shirai[2], Hiroka Kato[2], Sayuri Kato[3] (1.Department of Geography, Rissho University, 2.Department of Geography, Tokyo Metropolitan University, 3.Hamura City)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HQR05-10] Stratigraphy of Tokyo Formation: re-examination of Kita-Ku Central Park core

*Tomonori Naya[1], Kentaro Sakata[1], Tsutomu Nakazawa[1], Takehiko Suzuki[2], Toshio Nakayama[3] (1.Geological Survey of Japan, AIST, 2.Tokyo Metropolitan University, 3.Tokyo Metropolitan Government)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HQR05-11] S-wave veolocity structure and ground motion characteristics of "loam terraces": Examples from the eastern part of Utsunomiya City, Tochigi Prefecture, central Japan

★Invited Papers

*Tsutomu Nakazawa[1], Ikuo Cho[1], Kentaro Sakata[1] (1.Geological Survey of Japan, AIST)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HQR05-12] The relationship between liquefaction distribution and microtopography classification during the 1948 Fukui earthquake - Toward improvement of liquefaction hazard map -

*Haruka Tani[1], Masanobu Shishikura[2] (1.Housei University, 2.Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology)

[J] Poster | H (Human Geosciences)：H-QR Quaternary research

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_9

[H-QR05] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Masayuki Hyodo(Research Center for Inland Seas, Kobe University)

[HQR05-P01] Local marine reservoir age variability at Luzon Strait and Ryukyu Islands during the Holocene

*Shoko Hirabayashi[1,2,3], Yusuke Yokoyama[2,3], Atsushi Suzuki[4], Tezer Esat[5], Yosuke Miyairi[2], Takahiro AZE[2], Fernando Siringan[6], Yasuo Maeda[7], Hironobu Kan[1] (1.Graduate School of Social and Cultural Studies, Kyushu University, 2.Atmosphere and Ocean Research Institute The University of Tokyo, 3.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 4.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 5.Research School of Physics and Engineering, The Australian National University , 6.Marine Science Institute, University of the Philippines, 7.Institute of Natural and Environmental Sciences, University of Hyogo)

[HQR05-P02] Holocene sea-level and paleoenvironmental reconstruction using radiocarbon local marine reservoir age and geophysical modeling in Tongatapu, Kingdom of Tonga

*Naoto Fukuyo[1,2], Anthony Purcell[3], Geoffrey Clark[4], Phillip Parton[4], Yusuke Yokoyama[1,2], Yosuke Miyairi[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Department of Earth and Planetary Sciences, Faculty of Science, University of Tokyo, 3.Research School of Earth Sciences, The Australian National University, 4.College of Asia and the Pacific, Australian National University)

[HQR05-P03] The environmental change from lagoon sediment along Nakai Trough in Japan during the past 2000 years.

*Cho Ara[1], Kaoru Kashima[1], Jonathan D Woodruff[3], Koji Seto[2], Kazuyoshi Yamada[4], Kota Katsuki[2], Takumi Sato[2], Caroline Ladlow[3] (1.Kyushu University, 2.Shimane University, 3.University of Massachusetts, 4.Museum of Natural and Environmental History)

[HQR05-P04] Discovery and these sources of drift pumices interbedded in coastal sediments at Sekinehama, in the northern part of Shimokita peninsula, Aomori prefecture

*Reona Hiramine[1], Kaori Aoki[2], Daisuke Ishimura[1,2], Makoto Kobayashi[2] (1.Department of Geography, Tokyo Metropolitan University, 2.Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University)

[HQR05-P05] Comparison of geological stratigraphy between three drilling cores and analysis of shallow geological structure in the Koriyama Basin, Northeast Japan

*Takeshi ISHIHARA[1], Takehiko Suzuki[2] (1.Advanced Industrial Science and Technology, 2.Tokyo Metropolitan University)

[HQR05-P06] Holocene geomorphic development of the Kinu river system constrained by the dissected river valleys formed after MIS 5.

*Taiga Kimori[1], Toshihiko Sugai[2] (1.The University of Tokyo,Graduate School of Frontier Sciences,Dept. of Natural Environmental Studies, 2.The University of Tokyo)

[HQR05-P07] Depositional stratigraphy based on XRF, tephras and particle size analysis of core drilled in the central part of the Kanto plain, Sakai town, Ibaraki prefectural and Kuki city, Saitama prefecture (preliminary report)

*Tatsuki Miyamoto[1], Toshihiko Sugai[2], Kunihiko Endo[3], Natsuki Sasaki[2], Marie Noguchi[4], Sayuri Mitsuhashi[5] (1.Department of Earth and Planetary Environmental Science, The University of Tokyo, 2.Department of Natural Environmental Studies, Institute of Environmental Studies, Graduate School of Frontier Science, The University of Tokyo, 3.Nihon University, 4.Paleo Labo co.,ltd., 5.the Tone River Upstream River Office)

[HQR05-P08] Spatial distribution of Musashino Gravel in Tokyo using an automated program analyzing geological sequence from a vast number of boring data.

*Suginaka Yusuke[1], Kunihiko Endo[2], Shigeko Ishiwata, Toshihiko Sugai[3], Tatsuro Chiba[4], Taro Funatsu[3], Toshio Nakayama[5], Shinzaburo Hori[1] (1.Research Center of Computational Mechanics, Inc., 2.Nihon University, 3.Department of Natural Environmental Studies, Institute of Environmental Studies, Graduate School of Frontier Science, The University of Tokyo, 4.Asia air survay , 5.Tokyo metropolitan)

[HQR05-P09] Sedimentological features of Fuji-Sagamigawa Lahar deposits from the upper reaches of Sagami River, central Japan

*Masaaki Shirai[1], Mika Takehara[2], Takako UTSUGAWA[3] (1.Tokyo Metropolitan University, 2.Hachioji-City Office, 3.Rissho University)

[HQR05-P10] Terrace classification and geomorphological development process around Shinano river and Uono river junction area in Niigata prefecture

*Koseki Toshifumi[1], Mamoru Koarai[1] (1.Department of Earth Sciences, College of Science, Ibaraki University)

[HQR05-P11] Estimation of the Source of Sand Beach Sediment in Tsuruga Bay, Fukui Prefecture: Focusing on Grain Size Analysis and Composition of Clastics

*Akiko MATSUMOTO[1], Kiyokazu KAWAJIRI[2], Sumiko KUBO[1] (1.School of Education, Waseda Univ., 2.Sagamihara City Museun)

[HQR05-P12] Characteristics of Latest Pleistocene to Holocene deposits of two cores obtained from the inner part of the Nobi Plain, central Japan

*Kodai Hasada[1] (1.Faculty of Letters, Hosei University)

[HQR05-P13] Subsurface distribution of marine deposits during the MIS 5e and vertical displacement inferred from microfossil evidences and borehole logs in northern Ise Plain, central Japan

*Yoshiki Sato[1] (1.Advanced Industrial Science and Technology, Geological Survey of Japan)

[HQR05-P14] Detection of the Amagi-Kawagori tephra (Kg) in the Shijima lowland, the Shima Peninsula, and its significance to reconstruct tsunami history

Saki Yoshida[1], *Masanobu Shishikura[2], Hideaki Maemoku[1], Shigehiro Fujino[3] (1.Hosei University, 2.Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology, 3.University of Tsukuba)

[HQR05-P15] Holocene paleoenvironmental changes based on biomarker analysis at the western part of the Kawachi plain, Osaka, Japan

*Yukiko Ishino[1], Hideto Nakamura[1], Muneki Mitamura[1] (1.Osaka City University)

[HQR05-P16] Environmental change before and after Kikai-Akahoya tephra descent in the Miyazaki plain, Southern Kyushu

★Invited Papers

Mitsuhiro Kuwahata[2,7], Tatsuro Adachi[2], Yoshinori Tajiri[2], *Futoshi Nanayama[1,8], Shinji Sugiyama[6], Nakanishi Toshimichi[3], Ken'ichi Ohkushi[5], Tatsuhiko Yamaguchi[4] (1.Geological Survey of Japan, AIST, 2.Kyushu Univ., 3.Kyoto Univ., 4.Kochi Univ., 5.Kobe Univ., 6.Paleoenvironment Research Center Co. Ltd., 7.School board of Miyakonojyo City, 8.CWMD, Kumamoto University)

[HQR05-P17] The history of volcanic eruption based on tephrochronology at Plio-Pleistocene in Japan :2 Chronology of pyroclastic flow deposits in southern Kyushu

*Itoko Tamura[1], Kiyohide Mizuno[2] (1.Department of Geography,Graduate School of Urban Environmental Science,Tokyo Metropolitan University, 2.Research Institute of Geology and Geoinformation, Geological Survey of Japan, AIST)

[HQR05-P18] Identification of Ks5 tephra and similar tephras based on trace element composition of volcanic glass shards

*Hiroomi Nakazato[1], Futoshi Nanayama[2], Hisatoshi Ito[3], Shimpei Uesawa[3], Akira Furusawa[4], Kiyohide Mizuno[2] (1.National Agriculture and Food Research Organization, 2.National Institute of Advanced Industrial Science and Technology, 3.Central Research Institute of Electric Power Industry, 4.FURUSAWA Geological Survey)

[HQR05-P19] **Climate, vegetation and fire history of the last ~100 ka from archaeological sites of Belan valley, north-central India**

*Deepak Kumar Jha[1], Rahul Samrat[1], Prasanta Sanyal[1] (1.Department of Earth Scienes, Indian Institute of Science Education and Research Kolkata, Mohanpur -741246, India)

[J] Poster | H (Human Geosciences)：H-QR Quaternary research

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_16

[H-QR05] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Masayuki Hyodo(Research Center for Inland Seas, Kobe University)

[HQR05-P01] Local marine reservoir age variability at Luzon Strait and Ryukyu Islands during the Holocene

*Shoko Hirabayashi[1,2,3], Yusuke Yokoyama[2,3], Atsushi Suzuki[4], Tezer Esat[5], Yosuke Miyairi[2], Takahiro AZE[2], Fernando Siringan[6], Yasuo Maeda[7], Hironobu Kan[1] (1.Graduate School of Social and Cultural Studies, Kyushu University, 2.Atmosphere and Ocean Research Institute The University of Tokyo, 3.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 4.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 5.Research School of Physics and Engineering, The Australian National University , 6.Marine Science Institute, University of the Philippines, 7.Institute of Natural and Environmental Sciences, University of Hyogo)

[HQR05-P02] Holocene sea-level and paleoenvironmental reconstruction using radiocarbon local marine reservoir age and geophysical modeling in Tongatapu, Kingdom of Tonga

*Naoto Fukuyo[1,2], Anthony Purcell[3], Geoffrey Clark[4], Phillip Parton[4], Yusuke Yokoyama[1,2], Yosuke Miyairi[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Department of Earth and Planetary Sciences, Faculty of Science, University of Tokyo, 3.Research School of Earth Sciences, The Australian National University, 4.College of Asia and the Pacific, Australian National University)

[HQR05-P03] The environmental change from lagoon sediment along Nakai Trough in Japan during the past 2000 years.

*Cho Ara[1], Kaoru Kashima[1], Jonathan D Woodruff[3], Koji Seto[2], Kazuyoshi Yamada[4], Kota Katsuki[2], Takumi Sato[2], Caroline Ladlow[3] (1.Kyushu University, 2.Shimane University, 3.University of Massachusetts, 4.Museum of Natural and Environmental History)

[HQR05-P04] Discovery and these sources of drift pumices interbedded in coastal sediments at Sekinehama, in the northern part of Shimokita peninsula, Aomori prefecture

*Reona Hiramine[1], Kaori Aoki[2], Daisuke Ishimura[1,2], Makoto Kobayashi[2] (1.Department of Geography, Tokyo Metropolitan University, 2.Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University)

[HQR05-P05] Comparison of geological stratigraphy between three drilling cores and analysis of shallow geological structure in the Koriyama Basin, Northeast Japan

*Takeshi ISHIHARA[1], Takehiko Suzuki[2] (1.Advanced Industrial Science and Technology, 2.Tokyo Metropolitan University)

[HQR05-P06] Holocene geomorphic development of the Kinu river system constrained by the dissected river valleys formed after MIS 5.

*Taiga Kimori[1], Toshihiko Sugai[2] (1.The University of Tokyo,Graduate School of Frontier Sciences,Dept. of Natural Environmental Studies, 2.The University of Tokyo)

[HQR05-P07] Depositional stratigraphy based on XRF, tephras and particle size analysis of core drilled in the central part of the Kanto plain, Sakai town, Ibaraki prefectural and Kuki city, Saitama prefecture (preliminary report)

*Tatsuki Miyamoto[1], Toshihiko Sugai[2], Kunihiko Endo[3], Natsuki Sasaki[2], Marie Noguchi[4], Sayuri Mitsuhashi[5] (1.Department of Earth and Planetary Environmental Science, The University of Tokyo, 2.Department of Natural Environmental Studies, Institute of Environmental Studies, Graduate School of Frontier Science, The University of Tokyo, 3.Nihon University, 4.Paleo Labo co.,ltd., 5.the Tone River Upstream River Office)

[HQR05-P08] Spatial distribution of Musashino Gravel in Tokyo using an automated program analyzing geological sequence from a vast number of boring data.

*Suginaka Yusuke[1], Kunihiko Endo[2], Shigeko Ishiwata, Toshihiko Sugai[3], Tatsuro Chiba[4], Taro Funatsu[3], Toshio Nakayama[5], Shinzaburo Hori[1] (1.Research Center of Computational Mechanics, Inc., 2.Nihon University, 3.Department of Natural Environmental Studies, Institute of Environmental Studies, Graduate School of Frontier Science, The University of Tokyo, 4.Asia air survay , 5.Tokyo metropolitan)

[HQR05-P09] Sedimentological features of Fuji-Sagamigawa Lahar deposits from the upper reaches of Sagami River, central Japan

*Masaaki Shirai[1], Mika Takehara[2], Takako UTSUGAWA[3] (1.Tokyo Metropolitan University, 2.Hachioji-City Office, 3.Rissho University)

[HQR05-P10] Terrace classification and geomorphological development process around Shinano river and Uono river junction area in Niigata prefecture

*Koseki Toshifumi[1], Mamoru Koarai[1] (1.Department of Earth Sciences, College of Science, Ibaraki University)

[HQR05-P11] Estimation of the Source of Sand Beach Sediment in Tsuruga Bay, Fukui Prefecture: Focusing on Grain Size Analysis and Composition of Clastics

*Akiko MATSUMOTO[1], Kiyokazu KAWAJIRI[2], Sumiko KUBO[1] (1.School of Education, Waseda Univ., 2.Sagamihara City Museun)

[HQR05-P12] Characteristics of Latest Pleistocene to Holocene deposits of two cores obtained from the inner part of the Nobi Plain, central Japan

*Kodai Hasada[1] (1.Faculty of Letters, Hosei University)

[HQR05-P13] Subsurface distribution of marine deposits during the MIS 5e and vertical displacement inferred from microfossil evidences and borehole logs in northern Ise Plain, central Japan

*Yoshiki Sato[1] (1.Advanced Industrial Science and Technology, Geological Survey of Japan)

[HQR05-P14] Detection of the Amagi-Kawagori tephra (Kg) in the Shijima lowland, the Shima Peninsula, and its significance to reconstruct tsunami history

Saki Yoshida[1], *Masanobu Shishikura[2], Hideaki Maemoku[1], Shigehiro Fujino[3] (1.Hosei University, 2.Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology, 3.University of Tsukuba)

[HQR05-P15] Holocene paleoenvironmental changes based on biomarker analysis at the western part of the Kawachi plain, Osaka, Japan

*Yukiko Ishino[1], Hideto Nakamura[1], Muneki Mitamura[1] (1.Osaka City University)

[HQR05-P16] Environmental change before and after Kikai-Akahoya tephra descent in the Miyazaki plain, Southern Kyushu

★Invited Papers

Mitsuhiro Kuwahata[2,7], Tatsuro Adachi[2], Yoshinori Tajiri[2], *Futoshi Nanayama[1,8], Shinji Sugiyama[6], Nakanishi Toshimichi[3], Ken'ichi Ohkushi[5], Tatsuhiko Yamaguchi[4] (1.Geological Survey of Japan, AIST, 2.Kyushu Univ., 3.Kyoto Univ., 4.Kochi Univ., 5.Kobe Univ., 6.Paleoenvironment Research Center Co. Ltd., 7.School board of Miyakonojyo City, 8.CWMD, Kumamoto University)

[HQR05-P17] The history of volcanic eruption based on tephrochronology at Plio-Pleistocene in Japan :2 Chronology of pyroclastic flow deposits in southern Kyushu

*Itoko Tamura[1], Kiyohide Mizuno[2] (1.Department of Geography,Graduate School of Urban Environmental Science,Tokyo Metropolitan University, 2.Research Institute of Geology and Geoinformation, Geological Survey of Japan, AIST)

[HQR05-P18] Identification of Ks5 tephra and similar tephras based on trace element composition of volcanic glass shards

*Hiroomi Nakazato[1], Futoshi Nanayama[2], Hisatoshi Ito[3], Shimpei Uesawa[3], Akira Furusawa[4], Kiyohide Mizuno[2] (1.National Agriculture and Food Research Organization, 2.National Institute of Advanced Industrial Science and Technology, 3.Central Research Institute of Electric Power Industry, 4.FURUSAWA Geological Survey)

[HQR05-P19] **Climate, vegetation and fire history of the last ~100 ka from archaeological sites of Belan valley, north-central India**

*Deepak Kumar Jha[1], Rahul Samrat[1], Prasanta Sanyal[1] (1.Department of Earth Scienes, Indian Institute of Science Education and Research Kolkata, Mohanpur -741246, India)

[E] Poster | H (Human Geosciences)：H-SC Social Earth Sciences & Civil/Urban System Sciences

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_10

[H-SC06] Role of Geosciences for sustainable use of marine and coastal ecosystems in urbanized world.

convener:Kalpana Chaudhari(Institute For Sustainable Development and Research)

[HSC06-P01] Research on Diffusion Method of Factor in Urban Land Classification

★Invited Papers

*Jun Zhou[1] (1.Tianjin Normal University)

[HSC06-P02] Assessment of facilities for green tourism in Japan: Fifty-six indices in eight regions using online data

*Hanqiu Zhang[1], Qiongying Xiang[1], Jiaying Shi[1], Junchi Zhang[1], Yingming Mao[1], Kyung-hun Min[1], Ge Chen, Tokiya Oka[1], Zijiao Xie[1], Minami Kashima[1], I Made Pradnyan Dana Natawiguna, Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

[HSC06-P03] Study on Green Tourism Experience —— Cases of Popular Strawberry Farms in Chiba Prefecture

*Yilin Wu[1], Mengying Gao[1], Kazuhei Sato[1], Tingyu Lu[1], Fumeng Zhang[1], Siqi Xing[1], Karolina Brandt[1], Mai Uemura, Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

[HSC06-P04] **Ritual plant utilization in landscapes planning. Case study: Riverside in Denpasar City.**

*I Made Pradnyan Natawiguna[1], Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

[E] Poster | H (Human Geosciences)：H-SC Social Earth Sciences & Civil/Urban System Sciences

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_17

[H-SC06] Role of Geosciences for sustainable use of marine and coastal ecosystems in urbanized world.

convener:Kalpana Chaudhari(Institute For Sustainable Development and Research)

[HSC06-P01] Research on Diffusion Method of Factor in Urban Land Classification

★Invited Papers

*Jun Zhou[1] (1.Tianjin Normal University)

[HSC06-P02] Assessment of facilities for green tourism in Japan: Fifty-six indices in eight regions using online data

*Hanqiu Zhang[1], Qiongying Xiang[1], Jiaying Shi[1], Junchi Zhang[1], Yingming Mao[1], Kyung-hun Min[1], Ge Chen, Tokiya Oka[1], Zijiao Xie[1], Minami Kashima[1], I Made Pradnyan Dana Natawiguna, Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

[HSC06-P03] Study on Green Tourism Experience —— Cases of Popular Strawberry Farms in Chiba Prefecture

*Yilin Wu[1], Mengying Gao[1], Kazuhei Sato[1], Tingyu Lu[1], Fumeng Zhang[1], Siqi Xing[1], Karolina Brandt[1], Mai Uemura, Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

[HSC06-P04] **Ritual plant utilization in landscapes planning. Case study: Riverside in Denpasar City.**

*I Made Pradnyan Natawiguna[1], Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

[E] Oral | H (Human Geosciences)：H-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 106 1F

[H-TT20] Environmental Remote Sensing

convener:Wei Yang(Chiba University), Akihiko Kondoh(Center for Environmental Remote Sensing, Chiba University), Chairperson:Wei Yang(Chiba University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HTT20-01] Evaluation of Climate Change Impacts on Wetland Vegetation in the Dunhuang Yangguan National Nature Reserve in Northwest China Using Landsat Derived NDVI

*Feifei Pan[1] (1.University of North Texas)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HTT20-02] Characterizing the structure of the boundary layer under heavy pollution over urban area, Beijing, China

*LINLIN WANG[1] (1. Institute of Atmospheric Physics, Chinese Academy of Sciences)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HTT20-03] **THE STUDY OF RIVER CHANGE DETECTION INTEGRATING OBJECT-BASED CLASSIFICATION AND EDGE EXTRACTION**

*Yu-Chan Lee[1], Fang-Shii Ning[1], Hao-Che Ho[2] (1.Department of Land Economics, National Chengchi University, 2.Department of Civil Engineering, National Taiwan University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HTT20-04] **Monitoring winter wheat spring phenology in the North China Plain using MODIS**

*Xifang Wu[1], Wei Yang[2], Chunyang Wang[3], Yuki Sofue[4], Yanjun Shen[5], Akihiko Kondoh[2] (1.Graduate School of Science and Engineering , Chiba University, 2.Center for Environmental Remote Sensing, Chiba University, 3.School of Surveying and Land Information Engineering, Henan Polytechnic University, 4.Graduate School of Science, Chiba University, 5.Key Laboratory of Agricultural Water Resources, Center for Agricultural Resources Research, Institute of Genetics and Developmental Biology, Chinese Academy of Sciences)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HTT20-05] Assessment of numerous Data Assimilation Approaches in Regional Retrieval of Ground NO_2 Spatial Distribution via Remote Sensing products

*Hugo Wai Leung MAK[1,2], Jimmy Chi-Hung FUNG[1,2] (1.Department of Mathematics, Hong Kong University of Science and Technology, 2.Division of Environment and Sustainability, Hong Kong University of Science and Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HTT20-06] Spectro-polarimetric BRF measurement of leaves and model of individual leaf

*Begzsuren Tumendemberel[1], Yukihiro Takahashi[1], Tetsuro Ishida[1], Junichi Kurihara[1], Nobuyasu Naruse[2] (1.Hokkaido University, 2.Shiga University of Medical Science)

[E] Poster | H (Human Geosciences)：H-TT Technology & Techniques

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_11

[H-TT20] Environmental Remote Sensing

convener:Wei Yang(Chiba University), Akihiko Kondoh(Center for Environmental Remote Sensing, Chiba University)

[HTT20-P01] **Classification of Winter Wheat using high spatial resolution data in North China Plain**

*Chunyang Wang[1,2], Wei Yang[2], Xifang Wu[3], Zhichao Chen[1], Junjun Lu[1], Zongze Zhao[1], Hebing Zhang[1] (1.School of Surveying and Land Information Engineering, Henan Polytechnic University, 2.Center for Environmental Remote Sensing, Chiba University, 3.Graduate School of Science and Engineering, Chiba University)

[HTT20-P02] Normalized Difference Greenness Index (NDGI): A new vegetation index for improved estimation of vegetation phenology

*Wei Yang[1], Hideki Kobayashi[2], Akihiko Kondoh[1] (1.Chiba University, 2.JAMSTEC)

[HTT20-P03] ***Characteristics of manual and automatically tree species classification in mixed forest (Yamagata University Research Forest)***

*Sarah Kentsch[1,2], Larry Maximo Lopez Caceres[1], Yago Diez[1], Motohisa Fukuda[1] (1.Yamagata University, 2.United Graduate School of Agricultural Sciences)

[HTT20-P04] Land subsidence detection by SBAS-InSAR technology and its factor analysis in the inland area of Chiba Prefecture

*HALIPU AYIHUMAIER[1], Richa Bhattarai[1], Wen - LIU[1], Akihiko - Kondoh[1,2] (1.Graduate School of Science and Engineering, 2.Center for Environmental Remote Sensing, Chiba University)

[HTT20-P05] Development of a novel data fusion model to generate high spatiotemporal resolution NDVI time series

*Wei Yang[1], Jin Chen[2] (1.Chiba University, 2.Beijing Normal University)

[E] Poster | H (Human Geosciences)：H-TT Technology & Techniques

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_18

[H-TT20] Environmental Remote Sensing

convener:Wei Yang(Chiba University), Akihiko Kondoh(Center for Environmental Remote Sensing, Chiba University)

[HTT20-P01] **Classification of Winter Wheat using high spatial resolution data in North China Plain**

*Chunyang Wang[1,2], Wei Yang[2], Xifang Wu[3], Zhichao Chen[1], Junjun Lu[1], Zongze Zhao[1], Hebing Zhang[1] (1.School of Surveying and Land Information Engineering, Henan Polytechnic University, 2.Center for Environmental Remote Sensing, Chiba University, 3.Graduate School of Science and Engineering, Chiba University)

[HTT20-P02] Normalized Difference Greenness Index (NDGI): A new vegetation index for improved estimation of vegetation phenology

*Wei Yang[1], Hideki Kobayashi[2], Akihiko Kondoh[1] (1.Chiba University, 2.JAMSTEC)

[HTT20-P03] ***Characteristics of manual and automatically tree species classification in mixed forest (Yamagata University Research Forest)***

*Sarah Kentsch[1,2], Larry Maximo Lopez Caceres[1], Yago Diez[1], Motohisa Fukuda[1] (1.Yamagata University, 2.United Graduate School of Agricultural Sciences)

[HTT20-P04] Land subsidence detection by SBAS-InSAR technology and its factor analysis in the inland area of Chiba Prefecture

*HALIPU AYIHUMAIER[1], Richa Bhattarai[1], Wen - LIU[1], Akihiko - Kondoh[1,2] (1.Graduate School of Science and Engineering, 2.Center for Environmental Remote Sensing, Chiba University)

[HTT20-P05] Development of a novel data fusion model to generate high spatiotemporal resolution NDVI time series

*Wei Yang[1], Jin Chen[2] (1.Chiba University, 2.Beijing Normal University)

[J] Poster | H (Human Geosciences)：H-TT Technology & Techniques

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_12

[H-TT24] Environmental Remote Sensing

convener:Hiroto Shimazaki(National Institute of Technology, Kisarazu College), Akihiko Kondoh(Center for Environmental Remote Sensing, Chiba University), HASEGAWA Hitoshi(Kokushikan University), Teppei Ishiuchi(Miyagi University)

[HTT24-P01] A comparison and practical use of the landcover classification using ALOS/PALSAR and LANDSAT8/OLI

*Keiji Kimura[1] (1.Department of Geography, Nara University)

[HTT24-P02] A possibility of the identification of bottom sediment in shallow-water area using ALOS-3 image from a point of view for the environmental monitoring and protection in coastal areas

*YOSEI MIZUKAMI[1] (1.Japan Aerospace Exploration Agency)

[HTT24-P03] Evaluation of the impact of nomadism and settlement on grassland based on GPS observation data

*Deni Eer[1], Qinxue Wang[1], Tomohiro Okadera[1], Batkhishig Ochirbat[2] (1.National Institute for Environmental Studies, 2.Institute of Geography-Geoecology, Mongolian Academy of Sciences, Mongolia)

[J] Poster | H (Human Geosciences)：H-TT Technology & Techniques

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_19

[H-TT24] Environmental Remote Sensing

convener:Hiroto Shimazaki(National Institute of Technology, Kisarazu College), Akihiko Kondoh(Center for Environmental Remote Sensing, Chiba University), HASEGAWA Hitoshi(Kokushikan University), Teppei Ishiuchi(Miyagi University)

[HTT24-P01] A comparison and practical use of the landcover classification using ALOS/PALSAR and LANDSAT8/OLI

*Keiji Kimura[1] (1.Department of Geography, Nara University)

[HTT24-P02] A possibility of the identification of bottom sediment in shallow-water area using ALOS-3 image from a point of view for the environmental monitoring and protection in coastal areas

*YOSEI MIZUKAMI[1] (1.Japan Aerospace Exploration Agency)

[HTT24-P03] Evaluation of the impact of nomadism and settlement on grassland based on GPS observation data

*Deni Eer[1], Qinxue Wang[1], Tomohiro Okadera[1], Batkhishig Ochirbat[2] (1.National Institute for Environmental Studies, 2.Institute of Geography-Geoecology, Mongolian Academy of Sciences, Mongolia)

[J] Poster | H (Human Geosciences)：H-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_4

[H-CG29] Coastal wetlands: geomorphologic, biologic and anthropogenic processes

convener:Kiyoshi Fujimoto(Nanzan University)

[HCG29-P01] Progressing influences of rapid sea-level rise in the mangrove peat depositional area: Relationship between tree density of *Rhizophora* species and ground level dynamics

*Kiyoshi Fujimoto[1], Kenji Ono[2], Shin Watanabe[3], Shingo Taniguchi[3], Keita Furukawa[4], Yasumasa Hirata[2], Kodai Hasada[5], Saimon Lihpai[6] (1.Nanzan University, 2.Forestry and Forest Products Research Institute, 3.University of the Ryukyus, 4.Yokohama National University, 5.Hosei University, 6.Pohnpei State Government, FSM)

[HCG29-P02] Preliminary measurement of surface erosion and sedimentation in mangrove forests

*Keita Furukawa[1] (1.Graduate School Education Center, Yokohama National University)

[HCG29-P03] Estimation of fine root productivity of mangroves based on ingrowth core method on *Avicennia* forest in Panay Island, Philippines

*ONO Kenji[1], Rempei SUWA[2], Rene ROLLON[3], Ariel C. BLANCO[3], Giannina MARIE G. ALBANO[3], Green ANN A. CRUZ[3], Yasumin H. PRIMAVERA-TIROL[4], Ronald J. MALIO[4], Kazuo NADAOKA[5] (1.Forestry and Forest Products Research Institute, 2.Japan International Research Center for Agricultural Science, 3.University of the Philippines, 4.Aklan State University, 5.Tokyo Institute of Technology)

[HCG29-P04] The impact of reconstruction work for the ecosystem of marshes which appeared after Great East Japan Earthquake. A case of Nonoshima island, Shiogama, Miyagi prefecture.

*Rin Yamaguchi[1] (1.KyotoUniversity Faculty of letters)

[J] Poster | H (Human Geosciences)：H-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_20

[H-CG29] Coastal wetlands: geomorphologic, biologic and anthropogenic processes

convener:Kiyoshi Fujimoto(Nanzan University)

[HCG29-P01] Progressing influences of rapid sea-level rise in the mangrove peat depositional area: Relationship between tree density of *Rhizophora* species and ground level dynamics

*Kiyoshi Fujimoto[1], Kenji Ono[2], Shin Watanabe[3], Shingo Taniguchi[3], Keita Furukawa[4], Yasumasa Hirata[2], Kodai Hasada[5], Saimon Lihpai[6] (1.Nanzan University, 2.Forestry and Forest Products Research Institute, 3.University of the Ryukyus, 4.Yokohama National University, 5.Hosei University, 6.Pohnpei State Government, FSM)

[HCG29-P02] Preliminary measurement of surface erosion and sedimentation in mangrove forests

*Keita Furukawa[1] (1.Graduate School Education Center, Yokohama National University)

[HCG29-P03] Estimation of fine root productivity of mangroves based on ingrowth core method on *Avicennia* forest in Panay Island, Philippines

*ONO Kenji[1], Rempei SUWA[2], Rene ROLLON[3], Ariel C. BLANCO[3], Giannina MARIE G. ALBANO[3], Green ANN A. CRUZ[3], Yasumin H. PRIMAVERA-TIROL[4], Ronald J. MALIO[4], Kazuo NADAOKA[5] (1.Forestry and Forest Products Research Institute, 2.Japan International Research Center for Agricultural Science, 3.University of the Philippines, 4.Aklan State University, 5.Tokyo Institute of Technology)

[HCG29-P04] The impact of reconstruction work for the ecosystem of marshes which appeared after Great East Japan Earthquake. A case of Nonoshima island, Shiogama, Miyagi prefecture.

*Rin Yamaguchi[1] (1.KyotoUniversity Faculty of letters)

[J] Poster | H (Human Geosciences)：H-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_5

[H-CG30] Safety of nuclear power plants against inland earthquakes

convener:Daisuke Suetsugu(Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology), Satoshi Kaneshima(Department of Earth and Planetary Sciences, Kyushu University), Takeshi Sagiya(Disaster Mitigation Research Center, Nagoya University), Kohta Juraku(Department of Humanities, Social and Health Sciences, School of Engineering, Tokyo Denki University)

[HCG30-P01] Lessons from recent inland earthquakes in the Japan Islands

*Takeshi Sagiya[1] (1.Disaster Mitigation Research Center, Nagoya University)

[HCG30-P02] A review of inland earthquakes unlinked to active faults

*Daisuke Suetsugu[1] (1.Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology)

[HCG30-P03] Summary of 2018 JPGU session about the high-level radioactive waste disposal program

*Satoshi Kaneshima[1] (1.Department of Earth and Planetary Sciences, Kyushu University)

[HCG30-P04] Calculation Automates the Decision?: Socio-Technical Perspectives of Simulation Technology for Nuclear Risk Evaluation

*Kohta Juraku[1] (1.Department of Humanities, Social and Health Sciences, School of Engineering, Tokyo Denki University)

[J] Poster | H (Human Geosciences)：H-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_21

[H-CG30] Safety of nuclear power plants against inland earthquakes

convener:Daisuke Suetsugu(Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology), Satoshi Kaneshima(Department of Earth and Planetary Sciences, Kyushu University), Takeshi Sagiya(Disaster Mitigation Research Center, Nagoya University), Kohta Juraku(Department of Humanities, Social and Health Sciences, School of Engineering, Tokyo Denki University)

[HCG30-P01] Lessons from recent inland earthquakes in the Japan Islands

*Takeshi Sagiya[1] (1.Disaster Mitigation Research Center, Nagoya University)

[HCG30-P02] A review of inland earthquakes unlinked to active faults

*Daisuke Suetsugu[1] (1.Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology)

[HCG30-P03] Summary of 2018 JPGU session about the high-level radioactive waste disposal program

*Satoshi Kaneshima[1] (1.Department of Earth and Planetary Sciences, Kyushu University)

[HCG30-P04] Calculation Automates the Decision?: Socio-Technical Perspectives of Simulation Technology for Nuclear Risk Evaluation

*Kohta Juraku[1] (1.Department of Humanities, Social and Health Sciences, School of Engineering, Tokyo Denki University)

[J] Oral | H (Human Geosciences)：H-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 104 1F

[H-CG30] Safety of nuclear power plants against inland earthquakes

convener:Daisuke Suetsugu(Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology), Satoshi Kaneshima(Department of Earth and Planetary Sciences, Kyushu University), Takeshi Sagiya(Disaster Mitigation Research Center, Nagoya University), Kohta Juraku(Department of Humanities, Social and Health Sciences, School of Engineering, Tokyo Denki University), Chairperson:Daisuke Suetsugu, Kohta Juraku

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HCG30-01] Thickness of the seismogenic layer beneath the Japanese Islands and its relation to crustal earthquakes

*Junichi Nakajima[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HCG30-02] Problems with active fault evaluation in nuclear safety regulation

*Yasuhiro Suzuki[1] (1.Nagoya University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HCG30-03] The longer active fault is, is the larger ground motion generated? – Surface and buried rupture earthquakes-

*Takao Kagawa[1] (1.Tottori University Graduate School of Engineering)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HCG30-04] Seismic safety of nuclear power plants against inland crustal earthquakes and the "science vs. engineering problem"

*Katsuhiko Ishibashi[1] (1.Emeritus Professor, Kobe University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HCG30-05] Challenges to Seismic Safety of Nuclear Power Plants

*Tatsuya Itoi[1] (1.The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HCG30-06] Strong motion at Ooi nuclear power plant

*Kunihiko Shimazaki[1] (1.University of Tokyo)

[J] Poster | H (Human Geosciences)：H-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_5

[H-CG32] Interdisciplinary approach to earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Naofumi Yamaguchi(Center for Water Environment Studies, Ibaraki University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Hideko Takayanagi(Institute of Geology and Paleontology, Graduate School of Science, Tohoku University)

[HCG32-P01] Abration process of gravel considered from shape change of beach gravel in Joetsu region, Niigata Prefecture,central Japan

*Jun Matsukaze[1], Masaaki Shirai[1], Takako UTSUGAWA[2] (1.Tokyo Metropolitan University, 2.Rissho University)

[HCG32-P02] A meander bar in the upper Koito River changed by floods

*Hiroko Okazaki[1] (1.Division of ecology & environmentology, Natural History and Institute, Chiba)

[HCG32-P03] Depositional environment based on grain size of surface sediments around Okinoerabu-jima, Tokuno-shima and Amami-oshima Islands

*Atsuko Amano[1] (1.National institute of Advanced Industrial Science and Technology)

[HCG32-P04] Effect of organic matter input on bioturbation in submarine channel-levee deposits: an example of the Izaki Olistolith in the Oligocene Nichinan Group

*Kazuki Kikuchi[1], Hajime Naruse[1] (1.Division of Earth and Planetary Sciences, Guraduate School of Science, Kyoto University)

[HCG32-P05] Effect of Freeze-Thaw Cycles on Bank Erosion Rate of Bedrock

*Jagriti Mishra[1], Takuya Inoue[1] (1.Civil Engineering Research Institute for Cold Region, Sapporo - Hokkaido, Japan)

[HCG32-P06] Implications for paleoenvironment and tectonic setting of Khujirt area, Northern Mongolia

*Bat-Orshikh Erdenetsogt[1], Ariunbold Erdene[2] (1.National University of Mongolia, 2.ErdGeo LLC)

[HCG32-P07] Petrographic characteristics of Middle Permian sandstones in Southern Mongolia and their geological implications

*Enkhbayar Bolormaa[1], Dashpuntsag Nansalmaa[1], Bat-Orshikh Erdenetsogt[1], Baigalmaa Norov[1], Bat Bold[1], Luvsanchultem Jargal[1], Avirmed Tulga[1] (1.National Unniversity of Mongolia)

[J] Poster | H (Human Geosciences)：H-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_22

[H-CG32] Interdisciplinary approach to earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Naofumi Yamaguchi(Center for Water Environment Studies, Ibaraki University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Hideko Takayanagi(Institute of Geology and Paleontology, Graduate School of Science, Tohoku University)

[HCG32-P01] Abration process of gravel considered from shape change of beach gravel in Joetsu region, Niigata Prefecture,central Japan

*Jun Matsukaze[1], Masaaki Shirai[1], Takako UTSUGAWA[2] (1.Tokyo Metropolitan University, 2.Rissho University)

[HCG32-P02] A meander bar in the upper Koito River changed by floods

*Hiroko Okazaki[1] (1.Division of ecology & environmentology, Natural History and Institute, Chiba)

[HCG32-P03] Depositional environment based on grain size of surface sediments around Okinoerabu-jima, Tokuno-shima and Amami-oshima Islands

*Atsuko Amano[1] (1.National institute of Advanced Industrial Science and Technology)

[HCG32-P04] Effect of organic matter input on bioturbation in submarine channel-levee deposits: an example of the Izaki Olistolith in the Oligocene Nichinan Group

*Kazuki Kikuchi[1], Hajime Naruse[1] (1.Division of Earth and Planetary Sciences, Guraduate School of Science, Kyoto University)

[HCG32-P05] Effect of Freeze-Thaw Cycles on Bank Erosion Rate of Bedrock

*Jagriti Mishra[1], Takuya Inoue[1] (1.Civil Engineering Research Institute for Cold Region, Sapporo - Hokkaido, Japan)

[HCG32-P06] Implications for paleoenvironment and tectonic setting of Khujirt area, Northern Mongolia

*Bat-Orshikh Erdenetsogt[1], Ariunbold Erdene[2] (1.National University of Mongolia, 2.ErdGeo LLC)

[HCG32-P07] Petrographic characteristics of Middle Permian sandstones in Southern Mongolia and their geological implications

*Enkhbayar Bolormaa[1], Dashpuntsag Nansalmaa[1], Bat-Orshikh Erdenetsogt[1], Baigalmaa Norov[1], Bat Bold[1], Luvsanchultem Jargal[1], Avirmed Tulga[1] (1.National Unniversity of Mongolia)

[J] Oral | H (Human Geosciences)：H-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 105 1F

[H-CG32] Interdisciplinary approach to earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Naofumi Yamaguchi(Center for Water Environment Studies, Ibaraki University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Hideko Takayanagi(Institute of Geology and Paleontology, Graduate School of Science, Tohoku University), Chairperson:Koji Seike

1:50 PM - 2:20 PM JST | 4:50 AM - 5:20 AM UTC

[HCG32-01] Long-term beach observation and future shoreline prediction

★Invited Papers

*Masayuki Banno[1] (1.Port and Airport Research Institute)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[HCG32-02] Migration of sand waves observed in Okinose area of Osaka Bay

*Kojima Hibiki[1], Tetsuo Matsuno[2,3], Mamoru Sano[2], Nobukazu Seama[3,2], Noritaka Endo[4], Ken'ichi Ohkushi[1], Atsushi Tani[1] (1.Graduate School of Human Development and Environment, Kobe University, 2.Kobe Ocean Bottom Exploration Center(KOBEC), Kobe University, 3.Graduate School of Science / Faculty of Science, Kobe University, 4.School of Geoscience and Civil Engineering College of Science and Engineering, Kanazawa University)

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[HCG32-03] Inverse analysis of lobe/gully on Mars: examination by 2D Voellmy fluid model

Kyohei Noumura[1], *Hajime Naruse[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[HCG32-04] Development of provenance study using quartz shapes and surface microtextures

*Hiromi Itamiya[1], Ritsuko Sugita[1], Toshihiko Sugai[2] (1.National Research Institute of Police Science, 2.The University of Tokyo)

[J] Oral | H (Human Geosciences)：H-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 105 1F

[H-CG32] Interdisciplinary approach to earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Naofumi Yamaguchi(Center for Water Environment Studies, Ibaraki University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Hideko Takayanagi(Institute of Geology and Paleontology, Graduate School of Science, Tohoku University), Chairperson:Hideko Takayanagi(Tohoku University), Koji Seike

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HCG32-05] Detrital heavy mineral record and Nd-Sr isotopic signature in Bengal Fan

*Kohki Yoshida[1], Cruz Jarrett[2], Manoj M.C.[3], Nozomi Hatano[5], Christian France-Lanord[4], Takeshi Kuritani[6] (1.Department of Geology, Faculty of Science, Shinshu University, 2.Florida State University, 3.Birbal Sahni Institute of Palaeosciences, 4.CNRS- Universite de Lorraine, 5.Graduate School of Science and Technology, Shinshu University, 6.Hokkaido University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HCG32-06] Evaluation of plant-fragment concentration mechanism in the turbiditic sediments in the Bouma Sequence by biomarker analysis in the Kawabata Formation, Yubari area, central Hokkaido, Japan.

*Hiroyasu Asahi[1], Satoshi Furota[2], Ken Sawada[3] (1.Graduate School of Science, Hokkaido University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HCG32-07] Tectonic behavior of a forearc basin reconstructed using turbidites: an example from the Plio-Pleistocene Kakegawa Group, central Japan

*Sone Haruki[1] (1.Graduate school of Shimane University, Natural Science and Technology, Major in Science of Environmental systems, Geoscience corse)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HCG32-08] Most benthos floats up in liquefied sandy substrates: quantitative evaluation by measuring living-organism density

*Koji Seike[1], Shinji Sasa[2], Kotaro Shirai[3], Kaoru Kubota[4] (1.Geological Survey of Japan, AIST, 2.Port and Airport Research Institute, 3.AORI, The University of Tokyo, 4.Kochi Institute for Core Sample Research, JAMSTEC)

[J] Poster | H (Human Geosciences)：H-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_6

[H-CG33] Useful life-support systems in closed bio-ecosystems

convener:Kaori Tomita-Yokotani(Faculty of Life and Environmental Sciences University of Tsukuba), Masanori Shinohara(Teikyo University of Science), Shunta Kimura(Graduate School of Life and Environmental Sciences, University of Tsukuba)

[HCG33-P01] The important matter of food production for long term habitation in extraterrestrial environments

*Kaori Tomita-Yokotani[1] (1.Faculty of Life and Environmental Sciences University of Tsukuba)

[HCG33-P02] Functional evaluation of extracellular polymer substance (EPS) produced by cyanobacterium *Arthrospira platensis*

*Satoru Watanabe[1], Takumi Iwasaki[1], Yutaka Sakamaki[1], Yu Kanesaki[2], Masayuki Ohmori[3] (1.Dept. of Biosci., Tokyo Univ. of Agric., 2.RIGST, Shizuoka Univ., 3.Tokyo Univ.)

[HCG33-P03] The uniqueness of the dry heat tolerance of akinetes of terrestrial cyanobacterium *Nostoc* sp. HK-01

*Shunta Kimura[1,2,3], Kaori Tomita-Yokotani[3] (1.Graduate School of Agricultural and Life Sciences, The University of Tokyo, 2.Japan Society for the Promotion of Science, 3.Faculty of Life and Environmental Sciences, University of Tsukuba)

[HCG33-P04] Potential application of cyanobacteria estimated by gene analysis of terrestrial cyanobacterium, *Nostoc* sp. HK-01, in closed-environment

*Hiroshi Katoh[1], Shunta Kimura[2,3], Kaori Tomita-Yokotani[2] (1.Mie University, 2.University of Tsukuba, 3.The University of Tokyo)

[HCG33-P05] Analysis of macromolecular substances involved in the process of dehydration in a terrestrial cyanobacterium, *Nostoc* sp. HK-01.

*Tomoko Abe[1], Yuka Takazawa[1], Ryusuke Honda[1], Kouga Ichikawa[1], Natsumi Yoshida[1], Shunta Kimura[2,4], Hiroshi Katoh[3], Kaori Tomita-Yokotani[2] (1.School of Science and Engineering, Tokyo Denki University, 2.Faculty of Life and Environmental Sciences, University of Tsukuba, 3.Mie University, 4.Graduate School of Agricultural and Life Sciences, The University of Tokyo)

[J] Poster | H (Human Geosciences)：H-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_23

[H-CG33] Useful life-support systems in closed bio-ecosystems

convener:Kaori Tomita-Yokotani(Faculty of Life and Environmental Sciences University of Tsukuba), Masanori Shinohara(Teikyo University of Science), Shunta Kimura(Graduate School of Life and Environmental Sciences, University of Tsukuba)

[HCG33-P01] The important matter of food production for long term habitation in extraterrestrial environments

*Kaori Tomita-Yokotani[1] (1.Faculty of Life and Environmental Sciences University of Tsukuba)

[HCG33-P02] Functional evaluation of extracellular polymer substance (EPS) produced by cyanobacterium *Arthrospira platensis*

*Satoru Watanabe[1], Takumi Iwasaki[1], Yutaka Sakamaki[1], Yu Kanesaki[2], Masayuki Ohmori[3] (1.Dept. of Biosci., Tokyo Univ. of Agric., 2.RIGST, Shizuoka Univ., 3.Tokyo Univ.)

[HCG33-P03] The uniqueness of the dry heat tolerance of akinetes of terrestrial cyanobacterium *Nostoc* sp. HK-01

*Shunta Kimura[1,2,3], Kaori Tomita-Yokotani[3] (1.Graduate School of Agricultural and Life Sciences, The University of Tokyo, 2.Japan Society for the Promotion of Science, 3.Faculty of Life and Environmental Sciences, University of Tsukuba)

[HCG33-P04] Potential application of cyanobacteria estimated by gene analysis of terrestrial cyanobacterium, *Nostoc* sp. HK-01, in closed-environment

*Hiroshi Katoh[1], Shunta Kimura[2,3], Kaori Tomita-Yokotani[2] (1.Mie University, 2.University of Tsukuba, 3.The University of Tokyo)

[HCG33-P05] Analysis of macromolecular substances involved in the process of dehydration in a terrestrial cyanobacterium, *Nostoc* sp. HK-01.

*Tomoko Abe[1], Yuka Takazawa[1], Ryusuke Honda[1], Kouga Ichikawa[1], Natsumi Yoshida[1], Shunta Kimura[2,4], Hiroshi Katoh[3], Kaori Tomita-Yokotani[2] (1.School of Science and Engineering, Tokyo Denki University, 2.Faculty of Life and Environmental Sciences, University of Tsukuba, 3.Mie University, 4.Graduate School of Agricultural and Life Sciences, The University of Tokyo)

[J] Oral | H (Human Geosciences)：H-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 202 2F

[H-CG33] Useful life-support systems in closed bio-ecosystems

convener:Kaori Tomita-Yokotani(Faculty of Life and Environmental Sciences University of Tsukuba), Masanori Shinohara(Teikyo University of Science), Shunta Kimura(Graduate School of Life and Environmental Sciences, University of Tsukuba), Chairperson:Shunta Kimura

3:32 PM - 3:47 PM JST | 6:32 AM - 6:47 AM UTC

[HCG33-01] Closed bio-ecosystems in extraterrestrial environments-Research in closed bio-ecosystems

*Kaori Tomita-Yokotani[1] (1.Faculty of Life and Environmental Sciences University of Tsukuba)

3:47 PM - 4:07 PM JST | 6:47 AM - 7:07 AM UTC

[HCG33-02] Concept and Studies of Aquaculture in Space -In the Past and Future-

★Invited Papers

*Masato Endo[1] (1.Tokyo University of Marine Science and Technology)

4:07 PM - 4:27 PM JST | 7:07 AM - 7:27 AM UTC

[HCG33-03] Protection effects of gasotransmitters against oxidation damager in vascular endothelial cells

★Invited Papers

*Shigeki Yoshida[1] (1.University of Tsukuba)

4:27 PM - 4:42 PM JST | 7:27 AM - 7:42 AM UTC

[HCG33-04] Study on nutrition intake and food selection to maintain health for habitation in space

*Yasuko Kimura[1], Shunta Kimura[2,3], Hiroshi Katoh[4], Kaori Tomita-Yokotani[2] (1.Jumonji University, 2.University of Tsukuba, 3.The University of Tokyo, 4.Mie University)

4:42 PM - 4:57 PM JST | 7:42 AM - 7:57 AM UTC

[HCG33-05] Limit of "rational optimism", Earth as CELSS, and sustainability of human-being

*Masanori Shinohara[1] (1.Teikyo University of Science)

[E] Oral | S (Solid Earth Sciences)：S-SS Seismology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 301B 3F

[S-SS04] New methods for seismicity characterization

convener:Francesco Grigoli(ETH-Zurich, Swiss Seismological Service), Aitaro Kato(Earthquake Research Institute, the University of Tokyo), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Claudio Satriano(Institut de Physique du Globe de Paris), Chairperson:Francesco Grigoli(ETH-Zurich; Swiss Seismological Service)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS04-01] MyShake: A global smartphone seismic network to characterize urban earthquakes

*Richard M Allen[1], Qingkai Kong[1], Sarina Patel[1], Robert Martin-Short[1] (1.University of California Berkeley)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS04-02] Full waveform-based automatic monitoring of microseismic activity using high sampling rate records: application to Garpenberg mine (Sweden)

★Invited Papers

*Natalia Poiata[1,2], Kadek Hendrawan Palgunadi[3], Jannes Kinscher[4], Pascal Bernard[1], Francesca De Santis[4], Emmanuelle Klein[4] (1.Institut de Physique du Globe de Paris, France, 2.National Institute for Earth Physics, Romania, 3.King Abdullah University of Science and Technology, Thuwal, Saudi Arabia, 4.Institut National de l'Environnement Industriel et des Risques Ineris, Nancy, France)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS04-03] A deep convolutional neural network for localizing and detecting earthquake swarm activity based on full waveforms: Chances, challenges and questions

★Invited Papers

*Marius Kriegerowski[1,2], Gesa Maria Petersen[1,2], Hannes Vasyura Bathke[2], Matthias Ohrnberger[2] (1.German Research Centre for Geosciences Potsdam, Germany, 2.Inst. of Geosciences, University of Potsdam, Germany)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS04-04] **Fast Location Parameters Determination of Seismic Events from Few Seconds of P Wave Recorded at a Single Seismological Station Using Support Vector Machine Regression**

*Luis Hernan Ochoa Gutierrez[1], Carlos Alberto Vargas Jimenez[1], Luis Fernando Niño Vasquez[1] (1.Universidad Nacional de Colombia)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS04-05] Foreshock activity detection by a threshold-free matched-filter technique

*Shiro Hirano[1], Hironori Kawakata[1], Issei Doi[2] (1.Department of Physical Science, College of Science and Engineering, Ritsumeikan University, 2.Disaster Prevention Research Institute, Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SSS04-06] Automated seismic event detection and localization: An application to long-period seismicity at Aso Volcano influenced by large earthquake

*Andri Hendriyana[1,3], Takeshi Tsuji[1,2] (1.International Institute for Carbon-Neutral Energy Research, 2.Kyushu University, 3.Bandung Institute of Technology)

[E] Poster | S (Solid Earth Sciences)：S-SS Seismology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_13

[S-SS04] New methods for seismicity characterization

convener:Francesco Grigoli(ETH-Zurich, Swiss Seismological Service), Aitaro Kato(Earthquake Research Institute, the University of Tokyo), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Claudio Satriano(Institut de Physique du Globe de Paris)

[SSS04-P01] **Constraint of focal mechanisms of induced seismicity by using misfit angles based on known *in-situ* stress**

*Yusuke Mukuhira[1], Makoto Naoi[2], Michael C Fehler[3], Hirokazu Moriya[5], Takatoshi Ito[1], Hiroshi Asanuma[4], Markus O Häring[6] (1.Institute of Fluid Science, Tohoku University, 2.Disaster Prevention Research Institute, Kyoto University, 3.Earth Resources Laboratory, MIT, 4.FREA, AIST, 5.School of Engineering, Tohoku University, 6.Häring GeoProject)

[SSS04-P02] Kinematic slip imaging of the Mw 3.3 earthquake in the St. Gallen 2013 geothermal reservoir, Switzerland, using an isochrone back projection approach

*Claudio Satriano[1], Eszter Király-Proag[2], Pascal Bernard[1], Stefan Wiemer[2] (1.Institut de Physique du Globe de Paris, France, 2.ETH Swiss Federal Institute of Technology Zurich, Switzerland)

[SSS04-P03] **Monitoring induced seismicity with a single seismic station by combining coda wave interferometry with distance geometry solvers**

*Francesco Grigoli[1], Simone Cesca[2], Alessandro Vuan[3], Filippo Broggini[1], John Clinton[1], Stefan Wiemer[1] (1.ETH-Zurich, Switzerland, 2.GFZ-Potsdam, Germany, 3.OGS-Trieste, Italy)

[SSS04-P04] Automatic Earthquake Locating by Stacking Characteristic Functions in a Source Scanning Method

★Invited Papers

*Hilary Chang[1], Alison Malcolm[1], Frédérick Massin[2], Francesco Grigoli[2] (1.Memorial University of Newfoundland, Earth Sciences, Canada, 2. ETH Zurich, Department of Earth Sciences, Zürich, Switzerland)

[SSS04-P05] Earthquake nowcasting: further development and application to Japan

*Kazuyoshi Nanjo[1], John B. Rundle[2], Tetsuo Sakurada[3] (1.University of Shizuoka, 2.University of California at Davis, 3.SAKURADA&Company)

[E] Poster | S (Solid Earth Sciences)：S-SS Seismology

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_24

[S-SS04] New methods for seismicity characterization

convener:Francesco Grigoli(ETH-Zurich, Swiss Seismological Service), Aitaro Kato(Earthquake Research Institute, the University of Tokyo), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Claudio Satriano(Institut de Physique du Globe de Paris)

[SSS04-P01] **Constraint of focal mechanisms of induced seismicity by using misfit angles based on known *in-situ* stress**

*Yusuke Mukuhira[1], Makoto Naoi[2], Michael C Fehler[3], Hirokazu Moriya[5], Takatoshi Ito[1], Hiroshi Asanuma[4], Markus O Häring[6] (1.Institute of Fluid Science, Tohoku University, 2.Disaster Prevention Research Institute, Kyoto University, 3.Earth Resources Laboratory, MIT, 4.FREA, AIST, 5.School of Engineering, Tohoku University, 6.Häring GeoProject)

[SSS04-P02] Kinematic slip imaging of the Mw 3.3 earthquake in the St. Gallen 2013 geothermal reservoir, Switzerland, using an isochrone back projection approach

*Claudio Satriano[1], Eszter Király-Proag[2], Pascal Bernard[1], Stefan Wiemer[2] (1.Institut de Physique du Globe de Paris, France, 2.ETH Swiss Federal Institute of Technology Zurich, Switzerland)

[SSS04-P03] **Monitoring induced seismicity with a single seismic station by combining coda wave interferometry with distance geometry solvers**

*Francesco Grigoli[1], Simone Cesca[2], Alessandro Vuan[3], Filippo Broggini[1], John Clinton[1], Stefan Wiemer[1] (1.ETH-Zurich, Switzerland, 2.GFZ-Potsdam, Germany, 3.OGS-Trieste, Italy)

[SSS04-P04] Automatic Earthquake Locating by Stacking Characteristic Functions in a Source Scanning Method

★Invited Papers

*Hilary Chang[1], Alison Malcolm[1], Frédérick Massin[2], Francesco Grigoli[2] (1.Memorial University of Newfoundland, Earth Sciences, Canada, 2. ETH Zurich, Department of Earth Sciences, Zürich, Switzerland)

[SSS04-P05] Earthquake nowcasting: further development and application to Japan

*Kazuyoshi Nanjo[1], John B. Rundle[2], Tetsuo Sakurada[3] (1.University of Shizuoka, 2.University of California at Davis, 3.SAKURADA&Company)

[E] Poster | S (Solid Earth Sciences)：S-SS Seismology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_6

[S-SS05] Induced and triggered seismicity: case-studies, monitoring and modeling techniques

convener:Luca Urpi(Swiss Seismological Service - ETH Zurich), Bogdan Enescu(Department of Geophysics, Kyoto University), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Francesco Grigoli(ETH-Zurich, Swiss Seismological Service)

[SSS05-P01] Harmonic seismic waves excited by far-field earthquakes

*Osamu Murakami[1] (1.Tono Rearch Institute of Earthquake Science, Association for the Development of Earthquake Prediction)

[SSS05-P02] **Dynamic triggering of microseismicity around Yunnan following the 2004 Sumatra and 2012 Indian Ocean Earthquakes**

*Lu Li[1], Baoshan Wang[1,4], Zhigang Peng[2], Danning Li[3] (1.Institute of Geophysics, CEA, 2.Georgia Tech, 3.Yunnan Earthquake Agency, 4.USTC)

[SSS05-P03] Megathrust-inducing azimuthal seismic anisotropy in local and regional crusts

*Tae-Kyung Hong[1], Junhyung Lee[1], Ilgoo Kim[1], Seongjun Park[1] (1.Department of Earth System Sciences, Yonsei University)

[SSS05-P04] **A Novel Method to Estimate Fracture Permeability: Combining microseismic observational data and reservoir engineering model**

*Meihua Yang[1,2], Yusuke Mukuhira[2], Takatoshi Ito[2] (1.State Key Laboratory of Oil and Gas Geology and Exploitation, Chendu University of Technology (China) , 2.Institute of Fluid Science, Tohoku University (Japan))

[SSS05-P05] Doublet Earthquake Triggering for the April 2014 Events in the Solomon Islands

*Calvin Luiramo Qwana[1], Masatoshi Miyazawa[2], James Mori[2] (1.Graduate School of Science, Kyoto University, 2.DPRI, Kyoto Univ.)

[SSS05-P06] Thermal pressurization in a deep geological repository as a possible mechanism for fault reactivation

*Luca Urpi[1], Antonio Pio Rinaldi[1], Jonny Rutqvist[2], Stefan Wiemer[1] (1.Swiss Seismological Service, ETH Zurich, Switzerland, 2.Energy Geosceinces Division, LBNL, USA)

[E] Poster | S (Solid Earth Sciences)：S-SS Seismology

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_25

[S-SS05] Induced and triggered seismicity: case-studies, monitoring and modeling techniques

convener:Luca Urpi(Swiss Seismological Service - ETH Zurich), Bogdan Enescu(Department of Geophysics, Kyoto University), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Francesco Grigoli(ETH-Zurich, Swiss Seismological Service)

[SSS05-P01] Harmonic seismic waves excited by far-field earthquakes

*Osamu Murakami[1] (1.Tono Rearch Institute of Earthquake Science, Association for the Development of Earthquake Prediction)

[SSS05-P02] **Dynamic triggering of microseismicity around Yunnan following the 2004 Sumatra and 2012 Indian Ocean Earthquakes**

*Lu Li[1], Baoshan Wang[1,4], Zhigang Peng[2], Danning Li[3] (1.Institute of Geophysics, CEA, 2.Georgia Tech, 3.Yunnan Earthquake Agency, 4.USTC)

[SSS05-P03] Megathrust-inducing azimuthal seismic anisotropy in local and regional crusts

*Tae-Kyung Hong[1], Junhyung Lee[1], Ilgoo Kim[1], Seongjun Park[1] (1.Department of Earth System Sciences, Yonsei University)

[SSS05-P04] **A Novel Method to Estimate Fracture Permeability: Combining microseismic observational data and reservoir engineering model**

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[SSS05-P05] Doublet Earthquake Triggering for the April 2014 Events in the Solomon Islands

*Calvin Luiramo Qwana[1], Masatoshi Miyazawa[2], James Mori[2] (1.Graduate School of Science, Kyoto University, 2.DPRI, Kyoto Univ.)

[SSS05-P06] Thermal pressurization in a deep geological repository as a possible mechanism for fault reactivation

*Luca Urpi[1], Antonio Pio Rinaldi[1], Jonny Rutqvist[2], Stefan Wiemer[1] (1.Swiss Seismological Service, ETH Zurich, Switzerland, 2.Energy Geosceinces Division, LBNL, USA)

[E] Oral | S (Solid Earth Sciences)：S-SS Seismology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[S-SS05] Induced and triggered seismicity: case-studies, monitoring and modeling techniques

convener:Luca Urpi(Swiss Seismological Service - ETH Zurich), Bogdan Enescu(Department of Geophysics, Kyoto University), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Francesco Grigoli(ETH-Zurich, Swiss Seismological Service), Chairperson:Luca Urpi(ETH-Zurich; Swiss Seismological Service), Bogdan Enescu(Graduate Schoold of Science, Kyoto University), Francesco Grigoli(ETH-Zurich; Swiss Seismological Service), Yosuke Aoki

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS05-01] **Causality between induced seismicity b-value reduction and stress state of existing fractures**

★Invited Papers

*Yusuke Mukuhira[1], Michael C Fehler[2], Takatoshi Ito[1], Hiroshi Asanuma[3], Markus O Häring[4] (1.Institute of Fluid Science, Tohoku University, 2.ERL, Massachusetts Institute of Technology , 3.FREA, AIST, 4.Häring GeoProject)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS05-02] Micromechanical model connecting earthquake statistics and observed spatiotemporal changes in source parameters of fluid induced seismicity

*Daisuke Sato[1], Keisuke Yoshida[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Tohoku University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS05-03] Seismicity induced by Multi-cycle operation of Hutubi underground gas storage, Xinjiang, China

*Baoshan Wang[1,2], Bo Zhang[2], Zhanbo Ji[2], Jinxin Hou[2], Lu Li[2] (1.University of Science and Technology of China, 2.Institute of Geophysics, China Earthquake Administration)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS05-04] Investigating the origin of the Mw 5.4 Pohang, Korea, earthquake of November 15, 2017: the investigations and conclusions of the Overseas Research Advisory Committee (ORAC)

*Toshihiko Shimamoto[1], William Ellsworth[2], Shermin Ge[3], Domenico Giardini[4], John Townend[5] (1. Institute of Geology, China Earthquake Administration, 2.Stanford University, 3.University of Colorado Boulder, 4.ETH, Zurich, 5.Victoria University of Wellington)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS05-05] **Seismic Anisotropy Measured before and after the 2016 Kumamoto and Kaikoura earthquakes**

*Martha K Savage[1], Kenny Graham[1], Yosuke Aoki[2], Richard Arnold[1], Tomomi Okada[3], Yoshihisa Iio[4], Satoshi Matsumoto[5] (1.Victoria University of Wellington, 2.Earthquake Reserach Institute, University of Tokyo, 3.Tohoku University, Sendai 980-8578, Japan, 4.Kyoto University, Uji 611-0011, Japan, 5.Kyushu University, 2-5643-29 Shin'yama, Shimabara, Nagasaki, 855-0843, Japan)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS05-06] Long-term behavior of induced seismicity in the Val d'Agri basin (Southern Apennines, Italy).

★Invited Papers

*Luisa Valoroso[1], Luigi Improta[1], Samer Bagh[1], Davide Piccinini[1], Pasquale De Gori[1] (1.Istituto Nazionale di Geofisica e Vulcanologia)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Yoshinari Hayashi(Faculty of Safety Science, Kansai University), Dianshu Ju(Ohsaki Research Institute, Inc.)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SSS13-01] Investigation of the effect of jog deviations on Riedel fractures by three-dimensional elasto-plastic analysis

*Tomohiro Toyoda[1], Toshihiro Noda[2], Shotaro Yamada[1], Akira Asaoka[3] (1.Nagoya University, Graduate School of Engineering, 2.Nagoya University, Disaster Mitigation Research Center, 3.Association for the development of earthquake prediction)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SSS13-02] A survey on earthquake prediction and public warning in seismological community

*Yoshinari Hayashi[1] (1.Faculty of Societal Safety Sciences, Kansai University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SSS13-03] Long-period strong ground motion of the Tokyo Bay area during the events occurred in the plate triple junction area

*Tomiichi Uetake[1] (1.R&D Department, TEPCO research Institute, Tokyo Electric Power Company)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS13-04] **Time-frequency and engineering characteristics on offshore ground motion**

*CHEN Su[1], FU Lei[1], LI Xiaojun[1] (1.Institute of Geophysics, China Earthquake Administration)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS13-05] **Long-period Ground Motion from Hypothetical Megathrust Earthquakes along the Nankai Through using the Ambient Seismic Field**

*Loic Viens[1], Tomotaka Iwata[1] (1.Disaster Prevention Research Institute, Kyoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS13-06] Fault model and strong ground motion evaluation for the Nankai megathrust earthquake

*Dianshu Ju[1], Hiroyuki Fujiwara[2], Nobuyuki Morikawa[2] (1.Ohsaki Research Institute, Inc., 2.National Research Institute for Earth Science and Disaster Resilience)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Susumu Kurahashi(Aichi Institute of Technology), Masahiro Korenaga(Railway Technical Research Institute)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS13-07] One cause of the strong ground motion characteristics in Mukawa town during the 2018 Hokkaido eastern Iburi earthquake

*Nobuo TAKAI[1], Michiko Shigefuji[2], Takahiro Maeda[3], Masayoshi Ichiyanagi[1], Hiroaki Takahashi[1] (1.Hokkaido University, 2.Kyushu University, 3.NIED)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS13-08] Estimation of SMGA source model during the 2018 Hokkaido Eastern Iburi (Mw6.6) earthquake

*Susumu Kurahashi[1], Kojiro Irikura[1] (1.Aichi Institute of Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS13-09] Strong ground motion prediction for the source fault model of Futagawa and Hinagu active fault zones (1) -Construction of the basin velocity structure model-

*Kimiyuki Asano[1], Tomotaka Iwata[1], Masayuki Yoshimi[2], Hiroe Miyake[3], Haruko Sekiguchi[1], Shinichi Matsushima[1], Hiroshi Kawase[1], Fumiaki Nagashima[1], Hiroaki Yamanaka[4], Kosuke Chimoto[4], Nobuyuki Yamada[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Shigeki Senna[7], Takahiro Maeda[7], Atsushi Wakai[7], Asako Iwaki[7], Kaoru Jin[9], Hidetaka Saomoto[2], Seiji Tsuno[8], Masahiro Korenaga[8], Takeshi Sugiyama, Haruhiko Suzuki[9], Hisanori Matsuyama[9], Shunpei Manabe[9], Atsushi Yatagai[9], Shigeru Okamoto[10], Masaki Suehiro[10] (1.Disaster Prevention Research Institute, Kyoto University, 2.Geological Survey of Japan, AIST, 3.University of Tokyo, 4.Tokyo Institute of Technology, 5.Kochi University, 6.Kyushu University, 7.National Research Institute for Earth Science and Disaster Resilience, 8.Railway Technical Research Institute, 9.OYO Corporation, 10.Hanshin Consultants Co., Ltd.)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS13-10] Strong ground motion prediction for the source fault model of Futagawa and Hinagu active fault zones (2)-Strong ground motion prediction -

*Tomotaka Iwata[1], Kimiyuki Asano[1], Masayuki Yoshimi[2], Hiroe Miyake[3], Haruko Sekiguchi[1], Shinichi Matsushima[1], Hiroshi Kawase[1], Fumiaki Nagashima[1], Hiroaki Yamanaka[4], Kosuke Chimoto[4], Nobuyuki Yamada[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Shigeki Senna[7], Takahiro Maeda[7], Asako Iwaki[7], Kaoru Jin[7], Hidetaka Saomoto[2], Seiji Tsuno[8], Masahiro Korenaga[8], Syunpei Manabe[9], Haruhiko Suzuki[9], Hisanori Matsuyama[9], Yatagai Atsushi[9] (1.Disaster Prevention Research Institute, Kyoto University, 2.Geological Survey of Japan, AIST, 3.University of Tokyo, 4.Tokyo Institute of Technology, 5.Kochi University, 6.Kyushu University, 7.National Research Institute for Earth Science and Disaster Resilience, 8.Railway Technical Research Institute, 9.OYO Corporation)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS13-11] Near-surface geophysical survey and hearing survey of housing damages at Yasunaga district, Mashiki Town stricken by the 2016 Kumamoto Earthquakes

*Tomio INAZAKI[1], Takanori Ogahara[1], Hiroshi Kisanuki[2] (1.Public Works Research Institute, Tsukuba Central Institute, 2.PWRI (Present Address: OYO Corporation))

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SSS13-12] Evaluation on Influence of Shallow Subsurface Structures to Earthquake Ground Motions in the Kumamoto Plain, Using the Borehole Seismic Data

*Masahiro Korenaga[1], Seiji Tsuno[1], Hiroaki Yamanaka[2], Kosuke Chimoto[2] (1.Railway Technical Research Institute, 2.Tokyo Institute of Technology)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Kentaro Kasamatsu(Kajima Corporation), Kazuhito Hikima(Tokyo Electric Power Company Holdings, Inc.)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS13-13] Factors of large amplitude ground motions excited by small to moderate earthquakes
- Examination of KiK-net Kuriyama-nishi of the 2013 Tochigi-ken Hokubu Earthquake (Mj6.3) -

*Kentaro Kasamatsu[1], Kenichi Kato[2], Tetsushi Watanabe[2], Tetsuo Shiota[3] (1.Kajima Corporation, 2.Kobori Research complex inc., 3.Shikoku Electric Power CO.,Inc.)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS13-14] Source modeling and strong ground motion simulation in the Tokyo metropolitan area of the 1923 Kanto earthquake based on seismic intensity inversion analysis

*Fumino Suzuki[1], Kenichi Kato[1], Katsuhisa Kanda[1], Takashi Ikeda[1] (1.KOBORI RESEARCH COMPLEX INC.)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS13-15] A Simple Fault Model to Calculate Strong Ground Motions Including Fling Steps for the Main Shock of the 2016 Kumamoto Earthquake

*Atsushi Nozu[1], Yosuke Nagasaka[1], Shuanglan Wu[1] (1.Port and Airport Research Institute)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS13-16] Fling-steps displacements by the discrete wavenumber method

*SHUANGLAN WU[1], Atsushi Nozu[1], Yosuke Nagasaka[1] (1.PORT AND AIRPORT RESEARCH INSTITUTE)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS13-17] Extension of characterized source model for long-period strong motions near surface-rupture-earthquakes

*Kojiro Irikura[1], Susumu Kurahashi[1], Yasuhiro Matsumoto[2] (1.Aichi Institute of Technology, 2.KOZO_KEIKAKU Engineering, Inc.)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS13-18] A Study for the cause of earthquake damages by the 2014 Nakagano-ken Hokubu earthquake (M_J6.7) – consideration using the strong motion simulation –

*Kazuhito Hikima[1], Ryoichi Nakamura[2], Tomiichi Uetake[1] (1.Tokyo Electric Power Company Holdings, Inc., 2.Earthquake Research Institute, Univ. of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Yosuke Nagasaka(Port and Airport Research Institute), Masumi Yamada(Disaster Prevention Research Institute, Kyoto University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS13-19] Strong ground motion simulation of the Northern Osaka earthquake of June 18, 2018

*Yosuke Nagasaka[1], Atsushi Nozu[1] (1.Port and Airport Research Institute)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS13-20] **Strong Motion of the 2018 Mw 6.4 Hualien, Taiwan Earthquake and Its Impact on Seismic Design Code in Taiwan**

*Chun-Hsiang Kuo[1], Jyun-Yan Huang[1], Che-Min Lin[1], Kuo-Liang Wen[2] (1.NCREE National Center for Research on Earthquake Engineering of Taiwan, 2.NCU National Central University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS13-21] Simulation of Rupture Directivity Effect for the February 6, 2018 Hualien, Taiwan Earthquake

*Cheng-Feng Wu[1], Huey-Chu Huang[1] (1.Department of Earth and Environmental Sciences, National Chung Cheng University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS13-22] Strong motions and estimation of the sursurface soil structure for the 2018 Hualien earthquake in Taiwan

*Masumi Yamada[1], Ikuo Cho[2], Chun-Hsiang Kuo[3], Che-min Lin[3], Ken Miyakoshi[4], Yujia Guo[4], Takumi Hayashida[5], Yasuhiro Matsumoto[6], James Mori[1], Yin-Tung Yen[7], Keng-Chang Kuo[8] (1.Disaster Prevention Research Institute, Kyoto University, 2.National Institute of Advanced Industrial Science and Technology , 3.National Center for Research on Earthquake Engineering, 4.Geo-Research Institute, 5.Building Research Institute, 6.Kozo Keikaku Engineering, 7.Sinotech Engineering Consultants, 8.Kaohsiung university of Science and Technology)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS13-23] **Effect of Near Surface Geology on the Recorded Ground Motion of the Nepal Earthquake in Kumaon Himalaya**

*SOHAN LAL[1], Anand Joshi[1], M.L. Sharma[1] (1.Indian Institute of Technology Roorkee)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS13-24] Broadband Source Modeling for the Himalayan Collision Zone

*Hiroe Miyake[1], Babita Sharma[2], Kazuki Koketsu[1], Soma Nath Sapkota[3] (1.Earthquake Research Institute, University of Tokyo, 2.National Centre for Seismology, Ministry of Earth Sciences, India, 3.Department of Mine and Geology, Nepal)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Yoshiyuki Tanaka(Earth and Planetary Science, The University of Tokyo), Masayuki Kano(東北大学 大学院理学研究科 地球物理学専攻)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SSS16-01] Development of New GEONET Analysis Strategy

*yasuaki kakiage[1], satoshi abe[1], kazuyuki ohashi[1], hideo hamazaki[1], kazuyuki tanaka[1], satoshi kawamoto[1], yuki hatanaka[1] (1.GSI of Japan)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SSS16-02] Relationship between deformation of the forearc wedge of Southwest Japan and the 1707 Hoei earthquake

*Yukinobu Okamura[1], Masanobu Shishikura[1] (1.Research Institute of Earthquake and Vocano Geology, National Institute of Advanced Industrial Science and Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SSS16-03] A possible slow slip event beneath the Kii Peninsula inferred from historical tilt records in 1970's

*Masayuki Kano[1], Yasuyuki Kano[2] (1.Graduate school of science, Tohoku University, 2.Earthquake Research Institute, The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS16-04] The effect of the steady plate subduction in the case of southwest Japan

*Yuto Iwase[1], Takeo Ito[1] (1.Graduate School of Environmental Science, Nagoya University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS16-05] Development of Mechanical Coupling Model on Subducting Plate Interfaces

*Hiroshi Kimura[1], Takeo Ito[1], Keiichi Tadokoro[1], Ryohei Sasajima[2] (1.Department of Earth and Planetary Sciences, Nagoya University, 2.Research Center For Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS16-06] Monitoring vertical deformation with optical lattice clock –an application of relativistic geodesy

*Yoshiyuki Tanaka[1], Yuichi Imanishi[2], Yoshiaki Tamura[3] (1.Earth and Planetary Science, The University of Tokyo, 2.Earthquake Research Institute, The University of Tokyo, 3.Mizusawa VLBI Observatory, National Astronomical Observatory of Japan)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Yuji Himematsu(Graduate School of Science, Hokkaido University), Atsushi Mukai(Faculty of Urban Management, Fukuyama City University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS16-07] Surface Deformation before and after the 2016 Kumamoto Earthquake Detected by SAR

*Manabu Hashimoto[1] (1.Disaster Prevention Research Institute, Kyoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS16-08] Co- and post-seismic crustal deformations associated with the 2016 Kumamoto earthquake sequence using ALOS-2/PALSAR-2 data

*Yuji Himematsu[1], Masato Furuya[1] (1.Graduate School of Science, Hokkaido University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS16-09] GNSS time series analysis of postseismic deformation induced by 2016 Kumamoto earthquake (M7.3)

*Satoshi Fuwa[1], Mako Ohzono[1] (1.Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS16-10] **The viscoelastic crustal response to the magma discharge/recharge in the upper crust: implications for the uplift of the Aira caldera before and after the 1914 eruption of the Sakurajima volcano**

*Tadashi Yamasaki[1], Freysteinn Sigmundsson[2], Masato Iguchi[3] (1.Geological Survey of Japan, AIST, 2.Nordic Volcanological Center, University of Iceland, 3.DPRI, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS16-11] Factors controlling annual changes in groundwater migration in the fault fracture zone of Manpukuji fault

*Atsushi Mukai[1], Shigeaki Otsuka[2], Yoichi Fukuda[3] (1.Faculty of Urban Management, Fukuyama City University, 2.Kobe Gakuin University, 3.Graduate School of Science, Kyoto Univ.)

[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Takao Tabei(Department of Global Environment and Disaster Prevention, Faculty of Science and Technology, Kochi University), Takeo Ito

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS16-12] Rapid uplift in SW Taiwan caused by fold growth

*Yoshiki Takei[1], Youichiro Takada[2] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2.Hokkaido University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS16-13] Construction of GNSS monitoring system in Nepal for the earthquake potential evaluation in the Himalayan Frontal Zone

*Takao Tabei[1], Mako Ohzono[2], Kazuki Koketsu[3], Hiroe Miyake[3], Rajendra Bhandari[4], Janak B. Chand[4], Bishow R. Silwal[4], Soma N. Sapkota[4] (1.Department of Global Environment and Disaster Prevention, Faculty of Science and Technology, Kochi University, 2.Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University, 3.Earthquake Researech Institute, University of Tokyo, 4.Department of Mines and Geology, Nepal)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS16-14] The kinematic model along the Sumatran fault using a new dense GNSS observation (AGNeSS+) in Banda Aceh

*Takeo Ito[1], Takao Tabei[2], Fumiaki Kimata[3], Makoto OKUBO[2], Tadashi Yamashina[2], Cecep Pratama[4], Didik Sugiyanto[5], Mukusin Umar[5], Nazli Ismail[5], Irwandi Nurdin[5] (1.Nagoya Univ, 2.Kochi Univ, 3.Tono Research Institute of Earthquake Science, 4.Gadjah Mada University, 5.Syiah Kuala University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS16-15] Mechanical modeling of interseismic deformation in the Central Andes: implications for back-arc shortening

*Shaoyang Li[1,2], Fuqiang Shi[3], Marcos Moreno[4], Jun'ichi Fukuda[1] (1.Earthquake Research Institute, University of Tokyo, Tokyo, Japan, 2.Department of Earth and Environmental Sciences, The University of Iowa, Iowa City, IA, USA, 3.Shaanxi Earthquake Agency, Xi'an, China, 4.Departamento de Geofísica, Facultad de Ciencias Físicas y Matemáticas, Universidad de Concepción, Concepción, Chile)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS16-16] Inferring regional stress field based on SAR analysis and dynamic simulation of the 2018 Palu earthquake

*Takafumi Yokota[1], Ryosuke Ando[1], Yosuke Aoki[2] (1.Graduate School of Science, University of Tokyo , 2.Earthquake Research Institute, University of Tokyo)

[J] Poster | S (Solid Earth Sciences)：S-SS Seismology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_14

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University)

[SSS16-P01] Earthquake Potential in Central Costa Rica based on Geodetic Observations

*Luis Alejandro Carvajal Soto[1], Takeo Ito[1], Hiroshi Kimura[1], Marino Protti Quesada[2] (1.Nagoya University, Earthquake and Volcano Research Center, 2.Observatorio Vulcanológico y Sismológico de Costa Rica, Universidad Nacional)

[SSS16-P02] Crustal deformation along the Liupanshan fault zone derived from GPS

*Weitao Chen[1,2], Weijun Gan[2], Genru Xiao[3], Shiming Liang[2] (1.Development Research Center, China Earthquake Administration, 2.Institute of Geology, China Earthquake Administration, 3.East China University of Technology)

[SSS16-P03] Convergence boundary and velocity between Amur and Okhotsk plates in northern Hokkaido inferred by GNSS velocity data

*Chihiro Ito[1], Hiroaki Takahashi[2], Mako Ohzono[2] (1.Graduate School of Science, Hokkaido University, 2.Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University)

[SSS16-P04] Vertical deformation and repeating earthquakes in southeastern Hokkaido in the last 100 years

*Hiroaki Kobayashi[1,2], Kazuki Koketsu[1], Hiroe Miyake[1] (1.Earthquake Research Institute, The University of Tokyo, 2.Now at Kobori Research Complex. Inc.)

[SSS16-P05] Simple estimation of interplate coupling in the Kushiro-oki and the Nemuro-oki regions, eastern Hokkaido in Japan from onshore GNSS data

*Hiroki Aota[1], Mako Ohzono[2], Fumiaki Tomita[3], Hiroaki Takahashi[2] (1.Department of Earth and Planetary Sciences, School of Science, Hokkaido University. , 2.ISV, Faculty of Science, Hokkaido University, 3.Graduate School of Science, Hokkaido University)

[SSS16-P06] Estimation of the early afterslip location of the 2011 Tohoku-Oki earthquake using onshore GNSS and offshore pressure data

*Putra Maulida[1], Yusaku Ohta[1], Ryota Hino[1] (1.Graduate School of Science, Tohoku University)

[SSS16-P07] Heterogeneous rheology structure estimated by the postseismic deformation following the 2011 Tohoku-Oki earthquake (M_w9.0)

*Yoshiaki Ito[1,2], Satoshi Miura[2], Jun Muto[2], Yusaku Ohta[2], Takeshi Iinuma[3], James Daniel Paul Moore[4] (1.Mitsubishi Space Software Co., Ltd., 2.Graduate School of Science, Tohoku University, 3.Japan Agency for Marine-Earth Science and Technology, 4.Nanyang Technological University)

[SSS16-P08] Contribution of linear and non-linear viscoelastic relaxation as postseismic deformation following an earthquake

*Hiroyuki Hoshino[1], SHINICHI MIYAZAKI[2,1], Kazuro Hirahara[2] (1.Graduate school of science, Kyoto University, 2.Institute of Education, Research and Regional Cooperation for crisis Management Shikoku, Kagawa University)

[SSS16-P09] Estimation of fault parameter with maximum ΔCFS based on GNSS data

*Shuntaro Fukaya[1], Mako Ohzono[2] (1.School of Science, Hokkaido University, 2.ISV, Faculty of Science Hokkaido University)

[SSS16-P10] Coseismic deformation of the 2018 Lombok earthquake, Indonesia, revealed through InSAR measurements

*ERLAN SUMANJAYA[1], MASATO FURUYA[1] (1.Hokkaido University)

[SSS16-P11] Recent crustal deformations around Mt. Azuma revealed by InSAR time-series analysis

*Hiroshi Munekane[1], Tomokazu Kobayashi[1] (1.GSI of Japan)

[SSS16-P12] The Fault model of the 2017 earthquake (M5.6) in the Eastern flank of Mt. Ontake estimated from precise leveling survey data

*Masayuki Murase[1], Naoka Kitazume[1], Yoshiko Yamanaka[2], Takeshi Matsushima[3], Fumiaki Kimata[7], Hitoshi Yamashita Mori[1], Takamasa Hase[1], Yang Li[1], Kazuki Ofuchi[1], Takahiro Kunitomo[2], Yuta Maeda[2], Shinichiro Horikawa[2], Takashi OKUDA[2], Kenjiro Matsuhiro[2], Kazushi Tanoue[2], Kazunari Uchida[3], Yoshiko Teguri[3], Rintaro Miyamachi[3], Kaori Morita[3], Yoshikawa Shin[4], Hiroyuki Inoue[4], Isao Kageyama[5], Syuichi Hosokawa[5], Takahiro Yanada[5], Rinah Tanaka[1], Ryosuke Doke[6] (1.Department of Earth and Environmental Sciences, College of Humanities and Sciences, NIHON University, 2.Graduate School of Environmental Studies, Nagoya University, 3.Graduate School of Sciences, Kyushu University, 4.Graduate School of Sciences, Kyoto University, 5.Japan Meteorological Agency, 6.Hot Springs Research Institute of Kanagawa Prefecture, 7.Tono Research Institute of Earthquake Science)

[SSS16-P13] Detection ability of Crustal deformation by Slow Slip Events along the Nankai Trough subduction zone

*Kazuki Miyaoka[1], Reiko Kai[1], Takeshi Kimura[2], Takahiro Tsuyuki[3] (1.Japan Meteorological Agency, 2.National Research Institute for Earth Science and Disaster Resilience, 3.Meteorological Research Institute)

[SSS16-P14] An investigation into slow-slip detection capability of the Tokai Strainmenter Network

*Kazuyoshi Nanjo[1] (1.University of Shizuoka)

[SSS16-P15] A Study on Trend Component Estimation Method of Strain Time Series Data Using State Space Model

*Takahiro Tsuyuki[1] (1.Meteorological Research Institute)

[SSS16-P16] Rainfall correction of strainmeter data in consideration of the flow from the upper reaches (2)

Kazuhiro Kimura[1], *Akio Kobayashi[2] (1.Japan Meteorological Agency, 2.Meteorological Research Institute, Japan Meteorological Agency)

[SSS16-P17] Long-term slow slip event beneath the Shima Peninsula from 2017 to 2018

*Akio Kobayashi[1], Takahiro Tsuyuki[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

[SSS16-P18] non- fault slip source components of long-term SSE and the relation to interseismic process preparing for large earthquake generation

*Noa Mitsui[1], Takeo Ito[2] (1.Tono Research Institute of Earthquake Science, 2.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University)

[SSS16-P19] **Restart of the long-term slow slip events along the Nankai trough after the 2016 Kumamoto earthquake, Japan**

*Shinzaburo Ozawa[1], Hiroshi Yarai[1] (1.Geographical Survey Institute of Japan)

[SSS16-P20] Crustal deformation in the San-in Shear Zone as observed by a dense GNSS network

*Angela Meneses-Gutierrez[1], Takuya NISHIMURA[1] (1.Disaster Prevention Research Institute, Kyoto University)

[SSS16-P21] Two-dimensional Fourier series representation of surface deformation: Different scales of crustal deformation

*Akemi Noda[1], Tatsuhiko Saito[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[SSS16-P22] GNSS observation around the shear zone in southern Kyushu (The third report)

*Tsuyoshi Watanabe[1], Atsushi Saiga[2], Koichi Asamori[1], Hiroki Ogawa[1], Akiomi Shimada[1], Koji Umeda[3] (1.JAEA, Tono Geoscience Center, 2.JAEA, Horonobe Underground Research Center, 3.Hirosaki University)

[SSS16-P23] Post-seismic deformation of 2016 Kumamoto Earthquake by continuous GNSS network (3)

*Shigeru Nakao[1], Takeshi Matsushima[2], Takao Tabei[3], Makoto OKUBO[3], Tadashi Yamashina[4], Takahiro Ohkura[5], Takuya NISHIMURA[7,6], Takuo Shibutani[6], Masahiro Teraishi[6], Takeo Ito[7], Takeshi Sagiya[8], Kenjiro Matsuhiro[7], Teruyuki Kato[9], Jun'ichi Fukuda[9], Atsushi Watanabe[9], Satoshi Miura[10], Yusaku Ohta[10], Tomotsugu Demachi[10], Hiroaki Takahashi[11], Mako Ohzono[11], Teruhiro Yamaguchi[11], Kazumi Okada[11] (1.Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University, 2.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 3.Department of Global Environment and Disaster Prevenction, Faculty of Science and Technology, Kochi University,, 4.Kochi Earthquake Observatory, Faculty of Science and Technology ,Kochi University, 5.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School

of Science, Kyoto University, 6.Disaster Prevention Research Institute, Kyoto University, 7.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University, 8.Disaster Mitigation Research Center, Nagoya University, 9.Earthquake Research Institute, University of Tokyo, 10.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University,, 11.Institute of Seismology and Valcanology, Graduate School of Science, Hokkaido University)

[J] Poster | S (Solid Earth Sciences)：S-SS Seismology

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_26

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University)

[SSS16-P01] Earthquake Potential in Central Costa Rica based on Geodetic Observations

*Luis Alejandro Carvajal Soto[1], Takeo Ito[1], Hiroshi Kimura[1], Marino Protti Quesada[2] (1.Nagoya University, Earthquake and Volcano Research Center, 2.Observatorio Vulcanológico y Sismológico de Costa Rica, Universidad Nacional)

[SSS16-P02] Crustal deformation along the Liupanshan fault zone derived from GPS

*Weitao Chen[1,2], Weijun Gan[2], Genru Xiao[3], Shiming Liang[2] (1.Development Research Center, China Earthquake Administration, 2.Institute of Geology, China Earthquake Administration, 3.East China University of Technology)

[SSS16-P03] Convergence boundary and velocity between Amur and Okhotsk plates in northern Hokkaido inferred by GNSS velocity data

*Chihiro Ito[1], Hiroaki Takahashi[2], Mako Ohzono[2] (1.Graduate School of Science, Hokkaido University, 2.Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University)

[SSS16-P04] Vertical deformation and repeating earthquakes in southeastern Hokkaido in the last 100 years

*Hiroaki Kobayashi[1,2], Kazuki Koketsu[1], Hiroe Miyake[1] (1.Earthquake Research Institute, The University of Tokyo, 2.Now at Kobori Research Complex. Inc.)

[SSS16-P05] Simple estimation of interplate coupling in the Kushiro-oki and the Nemuro-oki regions, eastern Hokkaido in Japan from onshore GNSS data

*Hiroki Aota[1], Mako Ohzono[2], Fumiaki Tomita[3], Hiroaki Takahashi[2] (1.Department of Earth and Planetary Sciences, School of Science, Hokkaido University. , 2.ISV, Faculty of Science, Hokkaido University, 3.Graduate School of Science, Hokkaido University)

[SSS16-P06] Estimation of the early afterslip location of the 2011 Tohoku-Oki earthquake using onshore GNSS and offshore pressure data

*Putra Maulida[1], Yusaku Ohta[1], Ryota Hino[1] (1.Graduate School of Science, Tohoku University)

[SSS16-P07] Heterogeneous rheology structure estimated by the postseismic deformation following the 2011 Tohoku-Oki earthquake (M_w9.0)

*Yoshiaki Ito[1,2], Satoshi Miura[2], Jun Muto[2], Yusaku Ohta[2], Takeshi Iinuma[3], James Daniel Paul Moore[4] (1.Mitsubishi Space Software Co., Ltd., 2.Graduate School of Science, Tohoku University, 3.Japan Agency for Marine-Earth Science and Technology, 4.Nanyang Technological University)

[SSS16-P08] Contribution of linear and non-linear viscoelastic relaxation as postseismic deformation following an earthquake

*Hiroyuki Hoshino[1], SHINICHI MIYAZAKI[2,1], Kazuro Hirahara[2] (1.Graduate school of science, Kyoto University, 2.Institute of Education, Research and Regional Cooperation for crisis Management Shikoku, Kagawa University)

[SSS16-P09] Estimation of fault parameter with maximum ΔCFS based on GNSS data

*Shuntaro Fukaya[1], Mako Ohzono[2] (1.School of Science, Hokkaido University, 2.ISV, Faculty of Science Hokkaido University)

[SSS16-P10] Coseismic deformation of the 2018 Lombok earthquake, Indonesia, revealed through InSAR measurements

*ERLAN SUMANJAYA[1], MASATO FURUYA[1] (1.Hokkaido University)

[SSS16-P11] Recent crustal deformations around Mt. Azuma revealed by InSAR time-series analysis

*Hiroshi Munekane[1], Tomokazu Kobayashi[1] (1.GSI of Japan)

[SSS16-P12] The Fault model of the 2017 earthquake (M5.6) in the Eastern flank of Mt. Ontake estimated from precise leveling survey data

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[SSS16-P13] Detection ability of Crustal deformation by Slow Slip Events along the Nankai Trough subduction zone

*Kazuki Miyaoka[1], Reiko Kai[1], Takeshi Kimura[2], Takahiro Tsuyuki[3] (1.Japan Meteorological Agency, 2.National Research Institute for Earth Science and Disaster Resilience, 3.Meteorological Research Institute)

[SSS16-P14] An investigation into slow-slip detection capability of the Tokai Strainmenter Network

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[SSS16-P15] A Study on Trend Component Estimation Method of Strain Time Series Data Using State Space Model

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[SSS16-P16] Rainfall correction of strainmeter data in consideration of the flow from the upper reaches (2)

Kazuhiro Kimura[1], *Akio Kobayashi[2] (1.Japan Meteorological Agency, 2.Meteorological Research Institute, Japan Meteorological Agency)

[SSS16-P17] Long-term slow slip event beneath the Shima Peninsula from 2017 to 2018

*Akio Kobayashi[1], Takahiro Tsuyuki[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

[SSS16-P18] non- fault slip source components of long-term SSE and the relation to interseismic process preparing for large earthquake generation

*Noa Mitsui[1], Takeo Ito[2] (1.Tono Research Institute of Earthquake Science, 2.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University)

[SSS16-P19] **Restart of the long-term slow slip events along the Nankai trough after the 2016 Kumamoto earthquake, Japan**

*Shinzaburo Ozawa[1], Hiroshi Yarai[1] (1.Geographical Survey Institute of Japan)

[SSS16-P20] Crustal deformation in the San-in Shear Zone as observed by a dense GNSS network

*Angela Meneses-Gutierrez[1], Takuya NISHIMURA[1] (1.Disaster Prevention Research Institute, Kyoto University)

[SSS16-P21] Two-dimensional Fourier series representation of surface deformation: Different scales of crustal deformation

*Akemi Noda[1], Tatsuhiko Saito[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[SSS16-P22] GNSS observation around the shear zone in southern Kyushu (The third report)

*Tsuyoshi Watanabe[1], Atsushi Saiga[2], Koichi Asamori[1], Hiroki Ogawa[1], Akiomi Shimada[1], Koji Umeda[3] (1.JAEA, Tono Geoscience Center, 2.JAEA, Horonobe Underground Research Center, 3.Hirosaki University)

[SSS16-P23] Post-seismic deformation of 2016 Kumamoto Earthquake by continuous GNSS network (3)

*Shigeru Nakao[1], Takeshi Matsushima[2], Takao Tabei[3], Makoto OKUBO[3], Tadashi Yamashina[4], Takahiro Ohkura[5], Takuya NISHIMURA[7,6], Takuo Shibutani[6], Masahiro Teraishi[6], Takeo Ito[7], Takeshi Sagiya[8], Kenjiro Matsuhiro[7], Teruyuki Kato[9], Jun'ichi Fukuda[9], Atsushi Watanabe[9], Satoshi Miura[10], Yusaku Ohta[10], Tomotsugu Demachi[10], Hiroaki Takahashi[11], Mako Ohzono[11], Teruhiro Yamaguchi[11], Kazumi Okada[11] (1.Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University, 2.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 3.Department of Global Environment and Disaster Prevenction, Faculty of Science and Technology, Kochi University,, 4.Kochi Earthquake Observatory, Faculty of Science and Technology ,Kochi University, 5.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School

of Science, Kyoto University, 6.Disaster Prevention Research Institute, Kyoto University, 7.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University, 8.Disaster Mitigation Research Center, Nagoya University, 9.Earthquake Research Institute, University of Tokyo, 10.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University,, 11.Institute of Seismology and Valcanology, Graduate School of Science, Hokkaido University)

[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Masahiko Sato(Department of Earth and Planetary Science, University of Tokyo), Akira Baba(山梨県富士山科学研究所)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SEM18-01] On the formation process of the Mt.Hoei, Fuji volcano. A scenario based on the emplacement temperature inferred from paleomagnetic method.

*Akira Baba[1], Hidetoshi Shibuya[2], Toshitsugu Fujii[1], Tatsuro Chiba[3] (1.Mount Fuji Research Institute, 2.Department of Earth and Environmental Sciences, Faculty of Advanced Science and Technology, Kumamoto University, 3.Asia Air Survey Co., Ltd.)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SEM18-02] Reconstruction of paleointensity during 5 to 9 th century from Mt. Fuji lavas

Hiromichi Komatsu[2], *Tadahiro Hatakeyama[1,4], Akira Baba[3] (1.Information Processing Center, Okayama University of Science, 2.Faculty of Biosphere-Geosphere Science, Okayama University of Science, 3.Mount Fuji Research Institute, Yamanashi Prefecture, 4.Graduate School of Biosphere-Geosphere Science, Okayama University of Science)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SEM18-03] Reconstruction of full-vector archaeomagnetic reference curve in East Asia from 200 CE to 1100 CE

*Yu Kitahara[1], Daiki Nishiyama[2], Masao Ohno[1], Yuhji Yamamoto[3], Tadahiro Hatakeyama[4] (1.Faculty of Social and Cultural Studies, Kyushu University, 2.Faculty of Science, Kochi University, 3.Center for Advanced Marine Core Research, Kochi University, 4.Information Processing Center, Okayama University of Science)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SEM18-04] A high resolution paleomagnetic record across and around the Matuyama-Brunhes polarity transition from the Chiba composite section

*Makoto Okada[1], Yuki Haneda[2], Yusuke Suganuma[3,4] (1.Department of Earth Sciences, Faculty of Science, Ibaraki University, 2.Graduate School of Scinece and Engineering, Ibaraki Univeristy, 3.National Institute of Polar Research, 4.Graduate University for Advanced Studies)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SEM18-05] Brunhes-Matuyama contact aureole surrounding the Kurobegawa Granite

*Koji Fukuma[1], Hisatoshi Ito[2], Mami Takehara[3], Ryuji Yamada[4], Takashi Kubo[5] (1.Department of Environmental System Science, Faculty of Science and Engineering, Doshisha University, 2.Central Research Institute of Electric Power Industry, 3.National Institute of Polar Research, 4.National Research Institute for Earth Science and Disaster Prevention, 5.MAIBUNKAN)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SEM18-06] Paleomagnetic study of the IODP Site U1335 sediments in the eastern equatorial Pacific - relative paleointensity and inclination anomaly over the last 8 Myr

*Yuhji Yamamoto[1], Toshitsugu Yamazaki[2] (1.Center for Advanced Marine Core Research, Kochi University, 2.Atmosphere and Ocean Research Institute, University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Yu Kitahara(Graduate School of Social and Cultual Studies, Kyushu University), Hisayoshi Shimizu(The University of Tokyo)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SEM18-07] Sensor Response Estimate and Calibration of Superconducting Rock Magnetometers

*Hirokuni Oda[1], Chuang Xuan[2] (1.Institute of Geology and Geoinformation, Geological Survey of Japan, AIST, 2.University of Southampton)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SEM18-08] Magnetic separation of ordinary solid particles using a pokcet size magnetic circuit

*Chiaki Uyeda[1] (1.Institute of earth and Space Science Graduate School of Science Osaka University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SEM18-09] Experimental evaluation of remanence carriers in coercivity-blocking temperature diagram

*Masahiko Sato[1], Takuma Terada[2], Nobutatsu Mochizuki[3], Ayako Ito[2], Hideo Tsunakawa[2] (1.The University of Tokyo, 2.Tokyo Institute of Technology, 3.Kumamoto University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SEM18-10] **Mineralogical study on magnetite exsolution and host plagioclase crystal**

*Yujiro Tamura[1], Ryoichi Nakada[2], Masahiko Sato[3], Shinji Yamamoto[4] (1.Graduate schoole of Environment and Information Sciences, Departmennt of Natural Environment, Yokohama National University, 2.Kochi Institute of Core Sample Reserch, Japan Agency for Marine-Earth Science and Technology, 3.Department of Earth and Planetary Science, The University of Tokyo, 4.Graduate schoole of Environment and Information Sciences, Yokohama National University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SEM18-11] Numerous nano-sized magnetite and hematite inclusions in muscovite in loess

*Masayuki Hyodo[1], Takuro Sano[2], Megumi Matsumoto[3], Yusuke Seto[2], Kota Suzuki[2], Tianshui Yang[4] (1.Research Center for Inland Seas, Kobe University, 2.Graduate School of Science, Kobe University, 3.Graduate School of Science, Tohoku University, 4.China University of Geosciences)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SEM18-12] Density separation and magnetic measurements of magnetotactic bacteria *Magnetospirillum magnetotacticum* MS-1

*Kohei Masaoka[1], Yuki Morono[2], Naotaka Tomioka[2], Go-Ichiro Uramoto[1], Yuhji Yamamoto[1] (1.Kochi University, 2.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology)

[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Masahiko Sato(Department of Earth and Planetary Science, University of Tokyo), Hisayoshi Shimizu(The University of Tokyo)

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[SEM18-13] Effects of the intrinsic magnetic field on the atmospheric escape from terrestrial planets

★Invited Papers

*Kanako Seki[1], Shotaro Sakai[1], Shogo Inui[1], Ryoya Sakata[1], Naoki Terada[2], Hiroyuki Shinagawa[3], David A. Brain[4] (1.Graduate School of Science, University of Tokyo, 2.Graduate School of Science, Tohoku University, 3.NICT, 4.LASP, University of Colorado, Boulder)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[SEM18-14] Numerical modeling of a lunar dynamo and its long-term evolution

*Fumi Hyodo[1], Futoshi Takahashi[2], Satoshi Kaneshima[2], Hisayoshi Shimizu[3], Hideo Tsunakawa[4] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, Kyushu University, 3.Earthquake Research Institute, University of Tokyo, 4.Deparment of Earth and Planetary Sciences, Tokyo Institute of Technology)

2:20 PM - 2:40 PM JST | 5:20 AM - 5:40 AM UTC

[SEM18-15] Investigation of sub-grid scale (SGS) model in dynamo simulations with small Ekman and magnetic Prandtl numbers

★Invited Papers

*Hiroaki Matsui[1] (1.Dept. of Earth and Planetary Sciences, University of California, Davis)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SEM18-16] Growth rates of kinematic dynamos in a finite domain

*Ataru Sakuraba[1] (1.Department of Earth and Planetary Science, University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SEM18-17] Detection of jerk-like magnetic field variation in a numerical dynamo model using wavelet analysis

*Futoshi Takahashi[1], Yoshiki Manabe[2] (1.Faculty of Sciences, Kyushu University, 2.Department of Earth and Planetary Sciences, Kyushu University)

[J] Poster | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_15

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo)

[SEM18-P01] Analyzing the early 19th cenytury's geomagnetic declination in Japan from Tadataka Inoh's Santou-Houi-Ki the 13th roeport.

*Motohiro Tsujimoto[1], Akitoshi Omotani[2] (1.Japan Cartographers Association, 2.San-in System Consultant)

[SEM18-P02] Forecasting geomagnetic secular variation based on magnetic diffusion at the core-mantle boundary

*Masaki Matsushima[1], Hisayoshi Shimizu[2], Futoshi Takahashi[3], Takuto Minami[2], Shin ya Nakano[4], Hiroaki Toh[5] (1.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 2.Earthquake Research Institute, University of Tokyo, 3.Faculty of Science, Kyushu University, 4.Institute of Statistical Mathematics, 5.Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University)

[SEM18-P03] Candidate models of IGRF13-SV from Japanese team

*Hisayoshi Shimizu[1], Takuto Minami[1], Shin ya Nakano[2], Futoshi Takahashi[3], Masaki Matsushima[4], Hiroaki TOH[5] (1.Earthquake Research Institute, University of Tokyo, 2.Institute of Statistical Mathematics, 3.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 4.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology , 5.Data Analysis Center for Geomagnetism and Space Magnetism, Kyoto University)

[SEM18-P04] Preliminary report on the paleointensity variation during 38-50 Ma deduced from the marine sediments recovered from the northwest Atlantic

*Yuhji Yamamoto[1], Hiroto Fukami[1,2], Wakana Taniguchi[1], Peter C. Lippert[3] (1.Center for Advanced Marine Core Research, Kochi University, 2.Sanyo Techno Marine Co., Ltd., 3.Department of Geology and Geophysics, University of Utah)

[SEM18-P05] The Gauss-Matuyama polarity transition record from the Plio-Pleistocene marine sequence of the Mera Formation, Chikura Group, in the southernmost part of the Boso Peninsula

*Makoto Okada[1], Yosuke Hiraoka[2], Daisuke Hasegawa[2] (1.Department of Earth Sciences, Faculty of Science, Ibaraki University, 2.Graduate School of Science and Engineering, Ibaraki University)

[SEM18-P06] Holocene paleomagentic secular variation recorded in sediments from Lake Tazawa in Akita Prefecure, Northeast Japan

*Ryo Yasuda[1], Akira Hayashida[1], Kazuyoshi Yamada[2], Hiromi Matsuoka[3], Makoto Okamura[3], Daizo Ishiyama[4] (1.Doshisha University, 2.Museum of Natural and Environmental history, Shizuoka, 3.Kochi University, 4.Akita University)

[SEM18-P07] Geomagnetic excursions observed in Lake Suigetsu varved sediments during the latest stage of the last glacial period

*Shota Tanabe[1], Masako Miki[1], Masayuki Hyodo[2], Takeshi Nakagawa[3], Ikuko Kitaba[3], Keitaro Yamada[3], Junko Kitagawa[4], Suigetsu 2014 Project Members[5] (1.Kobe University, 2.Research Center for Inland Seas, Kobe University, 3.Ritsumeikan University, 4.Fukui Prefectural Satoyama-Satoumi Research Institute, 5.www.suigetsu.org)

[SEM18-P08] Geo-electromagnetic research at a spreading center of a divergent plate boundary in Afar depression, Ethiopia

*Naoto Ishikawa[1], Ryokei Yoshimura[2], Tesfaye Kidane[11], Shin-ichiro Higashino[3], Shin-ichi Kagashima[4], Nobutatsu Mochizuki[6], Ameha A. Muluneh[5], Kirika Kitagawa[4], Mamoru Kadoya[7], Noriaki Obara[10], Yo-ichiro Otofuji[9], Minoru Funaki, Tetsu Kogiso[1], Masakazu Fujii[8] (1.Graduate School of Human and Environmental Studies, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University, 3.Graduate School of Engineering, Kyushu University, 4.Yamagata University, 5.Addis Ababa University, 6.Kumamoto University, 7.X-TREME COMPOSITE JAPAN, 8.National Institute of Polar Research, 9.Japan Geochronology Network, 10.Robotista, 11.University of KwaZulu Natal)

[SEM18-P09] Verification of reducitive chemical demagnetization effect on the sedimentary rocks from the Kokumoto Formation, Kazusa Group, Boso Peninsula

*Takahiro Kitamura[1], Makoto Okada[1], Yuki Haneda[1], Chisato Anai[2], Hidetoshi Shibuya[2] (1.Ibaraki University, 2.Dep't Earth & Env. Sci., Kumamoto Univ.)

[SEM18-P10] Hole surface survey monitoring test using by rock magnetic analysis

*Noriko Kawamura[1], Naoto Ishikawa[2] (1.Japan Coast Guard Academy, 2.Graduate School of Human and Environmental Studies, Kyoto University)

[SEM18-P11] Rock magnetic measurements of Miocene dikes at the western margin of the Shitara Igneous Complex, central Japan

*Kohei Yamamoto[1], Hiroyuki Hoshi[2] (1.Graduate School of Education, Aichi University of Education, 2.Aichi University of Education)

[SEM18-P12] Eliminating spurious magnetic phases of sedimentary rocks using reductive chemical treatments – A thermomagnetic experiment study on the Upper Cretaceous Yezo Group-

*Chisato Anai[1], Hidetoshi Shibuya[1], Nobutatsu Mochizuki[1] (1.Kumamoto University)

[SEM18-P13] Rock-magnetic studies on seafloor hydrothermal deposits in the Okinawa Trough

*Chie Kato[1], Masao Ohno[1], Tadahiro Hatakeyama[2], Jun-ichiro Ishibashi[3], Shuhei Totsuka[4], Kazuhiko Shimada[3] (1.Department of Environmental Changes, Faculty of Social and Cultural Studies, Kyushu University, 2. Information Processing Center, Okayama University of Science, 3.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 4. Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University)

[SEM18-P14] Rock-magnetic study of fresh dunite in the Horoman peridotite complex, Hokkaido, Japan

*Nobutatsu Mochizuki[1], Satoko Ishimaru[1], Shoji Arai[2] (1.Department of Earth and Environmental Science, Faculty of Advanced Science and Technology, Kumamoto University, 2.Department of Earth Sciences, Faculty of Science, Kanazawa University)

[SEM18-P15] Improvements of sensitivity and utility in the scanning superconducting quantum interference device (SQUID) microscope

*Yusuke Kubota[1], Joseph Kirschvink[2,1], Isaac Hilburn[2], Jennifer Buz[3], Atsuko Kobayashi[1,2], Chie Kato[4] (1.Tokyo Institute of Technology, 2.California Institute of Technology, 3.Northern Arizona University, 4.Kyushu University)

[J] Poster | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_27

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo)

[SEM18-P01] Analyzing the early 19th cenytury's geomagnetic declination in Japan from Tadataka Inoh's Santou-Houi-Ki the 13th roeport.

*Motohiro Tsujimoto[1], Akitoshi Omotani[2] (1.Japan Cartographers Association, 2.San-in System Consultant)

[SEM18-P02] Forecasting geomagnetic secular variation based on magnetic diffusion at the core-mantle boundary

*Masaki Matsushima[1], Hisayoshi Shimizu[2], Futoshi Takahashi[3], Takuto Minami[2], Shin ya Nakano[4], Hiroaki Toh[5] (1.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 2.Earthquake Research Institute, University of Tokyo, 3.Faculty of Science, Kyushu University, 4.Institute of Statistical Mathematics, 5.Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University)

[SEM18-P03] Candidate models of IGRF13-SV from Japanese team

*Hisayoshi Shimizu[1], Takuto Minami[1], Shin ya Nakano[2], Futoshi Takahashi[3], Masaki Matsushima[4], Hiroaki TOH[5] (1.Earthquake Research Institute, University of Tokyo, 2.Institute of Statistical Mathematics, 3.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 4.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology , 5.Data Analysis Center for Geomagnetism and Space Magnetism, Kyoto University)

[SEM18-P04] **Preliminary report on the paleointensity variation during 38-50 Ma deduced from the marine sediments recovered from the northwest Atlantic**

*Yuhji Yamamoto[1], Hiroto Fukami[1,2], Wakana Taniguchi[1], Peter C. Lippert[3] (1.Center for Advanced Marine Core Research, Kochi University, 2.Sanyo Techno Marine Co., Ltd., 3.Department of Geology and Geophysics, University of Utah)

[SEM18-P05] The Gauss-Matuyama polarity transition record from the Plio-Pleistocene marine sequence of the Mera Formation, Chikura Group, in the southernmost part of the Boso Peninsula

*Makoto Okada[1], Yosuke Hiraoka[2], Daisuke Hasegawa[2] (1.Department of Earth Sciences, Faculty of Science, Ibaraki University, 2.Graduate School of Science and Engineering, Ibaraki University)

[SEM18-P06] Holocene paleomagentic secular variation recorded in sediments from Lake Tazawa in Akita Prefecure, Northeast Japan

*Ryo Yasuda[1], Akira Hayashida[1], Kazuyoshi Yamada[2], Hiromi Matsuoka[3], Makoto Okamura[3], Daizo Ishiyama[4] (1.Doshisha University, 2.Museum of Natural and Environmental history, Shizuoka, 3.Kochi University, 4.Akita University)

[SEM18-P07] Geomagnetic excursions observed in Lake Suigetsu varved sediments during the latest stage of the last glacial period

*Shota Tanabe[1], Masako Miki[1], Masayuki Hyodo[2], Takeshi Nakagawa[3], Ikuko Kitaba[3], Keitaro Yamada[3], Junko Kitagawa[4], Suigetsu 2014 Project Members[5] (1.Kobe University, 2.Research Center for Inland Seas, Kobe University, 3.Ritsumeikan University, 4.Fukui Prefectural Satoyama-Satoumi Research Institute, 5.www.suigetsu.org)

[SEM18-P08] Geo-electromagnetic research at a spreading center of a divergent plate boundary in Afar depression, Ethiopia

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[SEM18-P15] Improvements of sensitivity and utility in the scanning superconducting quantum interference device (SQUID) microscope

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[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT20] Property and role of liquids inside terrestrial planets

convener:Tatsuya Sakamaki(Department of Earth Science, Tohoku University), Yoichi Nakajima(Kumamoto University, Priority Organization for Innovation and Excellence), Chairperson:Tatsuya Sakamaki(Tohoku University), Yoichi Nakajima(Kumamoto University)

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[SIT20-01] Ultrahigh pressure structure change in SiO_2 glass with coordination number >6

★Invited Papers

*Yoshio Kono[1], Yu Shu[2], Curtis Kenney-Benson[2], Yanbin Wang[3], Guoyin Shen[2] (1.Geodynamics Research Center, Ehime University, 2.Argonne National Laboratory, 3.The University of Chicago)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SIT20-02] **Scaling pseudotachylytes from the lab to the field**

*Thomas P. Ferrand[1], Alexandre Schubnel[2], Nadège Hilairet[3], Loïc Labrousse[4], Stefan Nielsen[5] (1.Earthquake Research Institute, 2.Ecole Normale Supérieure, Paris, France, 3.Unité Matériaux et Transformations, Université de Lille, France, 4.Sorbonne Université, Institut des Sciences de la Terre Paris, France, 5.Department of Earth Sciences, Durham University, United Kingdom)

11:30 AM - 12:00 PM JST | 2:30 AM - 3:00 AM UTC

[SIT20-03] *Ab initio* molecular dynamics study of atomic diffusion in covalent liquid under high pressure

★Invited Papers

*Satoshi Ohmura[1], Taku Tsuchiya[2] (1.Hiroshima Institute of Technology, 2.Ehime University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SIT20-04] **Pressure-induced structural change in magnesium silicate melts**

*Toshiaki Iitaka[1], Nguyen Van Hong[2] (1.RIKEN, 2.Hanoi University of Science and Technology)

[E] Poster | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_16

[S-IT20] Property and role of liquids inside terrestrial planets

convener:Tatsuya Sakamaki(Department of Earth Science, Tohoku University), Yoichi Nakajima(Kumamoto University, Priority Organization for Innovation and Excellence)

[SIT20-P01] Melting relations in the Fe-P system at high pressures

*Yoichi Nakajima[1,2], Haruki Obata[2], Daisuke Kinoshita[2], Shigehiko Tateno[3], Kei Hirose[3,4], Naohisa Hirao[5], Saori I. Kawaguchi[5], Yasuo Ohishi[5] (1.Priority Organization for Innovation and Excellence, Kumamoto University, 2.Department of Phsyics, Kumamoto University,, 3.Earth-Life Science Institue, Tokyo Institute of Technology, 4.Department of Earth and Planertary Science, The University of Tokyo, 5.JASRI)

[SIT20-P02] Elastic property and structure of pyrope glass at high pressure

*Naoki Hisano[1], Tatsuya Sakamaki[1], Tomonori Ohashi[1], Ken-ichi Funakoshi[2], Yuji Higo[3], Yuki Shibazaki[4], Akio Suzuki[1] (1.Department of Earth Science, Graduate School of Science, Tohoku University, 2.Neutron Science & Technology Center, Comprehensive Research Organization for Science and Society (CROSS), 3.Japan Synchrotron Radiation Research Institute, 4.International Center for Young Scientists, National Institute for Materials Science)

[SIT20-P03] The effect of water and redox state on melting at the top of the lower mantle

*Ayano Nakajima[1], Tatsuya Sakamaki[1], Akio Suzuki[1] (1.Tohoku University)

[SIT20-P04] Sound velocity measurements on liquid Fe-P alloy up to 80 GPa

*Daisuke Kinoshita[1], Yoichi Nakajima[1,2], Yasuhiro Kuwayama[2,3], Kei Hirose[3], Daisuke Ishikawa[2,4], Baron Q.R. Alfred[2] (1.Kumamoto University, 2.RIKEN MDL, 3.Tokyo University, 4.JASRI)

[SIT20-P05] High-pressure structural investigations for hydrous sodium silicate melts

*Tomonori Ohashi[1], Tatsuya Sakamaki[1], Ken-ichi Funakoshi[2], Miki Muranushi[1], Chikara Shito[1], Yuki Shibazaki[3], Akio Suzuki[1] (1.Department of Earth Science, Tohoku University, 2.Neutron Science and Technology Center, Comprehensive Research Organization for Science and Society (CROSS), 3.National Institute for Materials Science (NIMS))

[SIT20-P06] Inelastic X-ray scattering measurements of liquid Fe-N alloy under high pressure

*Asaki Iwamoto[1], Yoichi Nakajima[1,2], Daisuke Kinoshita[1], Yasuhiro Kuwayama[2,3], Kei Hirose[3], Daisuke Ishikawa[2,4], Alfred Q.R. Baron[2] (1.Kumamoto University, 2.RIKEN MDL, 3.The University of Tokyo, 4.JASRI)

[SIT20-P07] Formation of highly pure anorthite crust on the low-volatile astral bodies by low-viscous magma ocean

*Tatsuya Sakamaki[1], Yoshio Kono[2] (1.Graduate School of Science, Tohoku University, 2.Geodynamics Research Center, Ehime University)

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5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_28

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10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_7

[S-IT23] Structure and Dynamics of Earth and Planetary Mantles

convener:Takashi Nakagawa(Department of Earth Sciences, The University of Hong Kong), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Dapeng Zhao(Department of Geophysics, Tohoku University)

[SIT23-P01] Interaction between volcanisms inland and the spreading center: example of Galápagos archipelago

*Walid Ben Mansour[1], Guust Nolet[2], Mario Ruiz[3], Juan Carlos Afonso[1] (1.Department of Earth and Planetary Sciences, Macquarie University, Sydney (Australia), 2.Geoazur, Université Cote d'Azur, Sophia Antipolis (France), 3.Instituto Geofisco, Escuela Politecnica Nacional, Quito (Ecuador))

[SIT23-P02] **Effect of iron content on thermal conductivity of olivine with implications for cooling history of rocky planets**

*Youyue Zhang[1], Takashi Yoshino[1], Akira Yoneda[1], Masahiro Osako[2] (1.Institute for Planetary Materials, Okayama University, 2.Division of Physical Sciences, National Museum of Nature and Science)

[SIT23-P03] **The distribution of Cenozoic conglomerates and its sedimentological constraint on the uplift of the South Tianshan, NW China**

*SUN HAITAO[1] (1.China University of Petroluem-Beijing)

[SIT23-P04] **Electrical conductivity of diaspore, δ-AlOOH and ε-FeOOH**

*Ran Wang[1] (1.Institute for Planetary Materials, Okayama University)

[SIT23-P05] Multi-mode surface wave tomography for azimuthal anisotropy in the Australasian upper mantle

*Yuka Nishimura[1], Kazunori Yoshizawa[2] (1. Graduate School of Science, Hokkaido University, 2.Faculty of Science, Hokkaido University)

[SIT23-P06] Mapping multi-mode surface wave phase speeds in North America using mode-branch waveforms decomposed by linear Radon transform

*Hitoshi Matsuzawa[1], Kazunori Yoshizawa[2] (1.Graduate School of Science, Hokkaido University, 2.Faculty of Science, Hokkaido University)

[SIT23-P07] Radial anisotropy in the upper mantle using multi-mode surface waves incorporating the η_K parameter: Application to the Pacific and Australian regions

Shuya Okuyama[1], *Kazunori Yoshizawa[1,2], Hitoshi Kawakatsu[3], Takehi Isse[3] (1.Graduate School of Science, Hokkaido University, 2.Faculty of Science, Hokkaido University, 3.Earthquake Research Institute, University of Tokyo)

[SIT23-P08] Pure to impure and dry to wet olivine rheology based on high temperature dependency of diffusion creep

*Kosuke Yabe[1], Takehiko Hiraga[1] (1.School of Science, The University of Tokyo)

[SIT23-P09] Finite frequency S wave tomography model beneath the Ontong Java Plateau using data recorded by broadband ocean bottom seismographs

*Misaki Horiuchi[3], Hiroko Sugioka[3], Masayuki Obayashi[1], Daisuke Suetsugu[1], Hajime Shiobara[2], Aki Ito[1], Yasushi Ishihara[1], Satoru Tanaka[1], Takehi Isse[2], Takashi Tonegawa[1], Junko Yoshimitsu[1], Takumi Kobayashi[3] (1.Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan, 2.Earthquake Research Institute, The University of Tokyo, Tokyo, Japan, 3.The University of Kobe, Hyogo, Japan)

[SIT23-P10] Shear wave structure of the upper mantle beneath the Ontong Java Plateau

*Takehi Isse[1], Daisuke Suetsugu[2], Hajime Shiobara[1], Hiroko Sugioka[3], Aki Ito[2], Yasushi Ishihara[2], Satoru Tanaka[2], Masayuki Obayashi[2], Takashi Tonegawa[2], Junko Yoshimitsu[2], Takumi Kobayashi[3], Kazunori Yoshizawa[4] (1.Earthquake Research Institute University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Kobe University, 4.Faculty of Science, Hokkaido University)

[SIT23-P11] Effect of impurity on post-post-perovskite transition of $MgSiO_3$ by first principles

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[SIT23-P12] Unsusual high-Ti corundum recovered from the Horoman peridotites, Hokkaido, Japan

*oosawa takumi[1], Shinji Yamamoto[1] (1.yokohama national university)

[SIT23-P13] Deformation experiments on akimotoite

*Longli Guan[1], Daisuke Yamazaki[1], Noriyoshi Tsujino[1] (1.Institute for Planetary Materials, Okayama University, Misasa, Japan)

[SIT23-P14] Fate of water in subducted hydrous sediments deduced from stability fields of FeOOH and AlOOH up to 20 GPa

*Takashi Yoshino[1], Edward Baker[2], Kyle Duffey[3] (1.Institute for Planetary Materials, Okayama University, 2.Department of Earth Sciences, University of Oxford, 3.Department of Geosciences, Princeton University)

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*oosawa takumi[1], Shinji Yamamoto[1] (1.yokohama national university)

[SIT23-P13] Deformation experiments on akimotoite

*Longli Guan[1], Daisuke Yamazaki[1], Noriyoshi Tsujino[1] (1.Institute for Planetary Materials, Okayama University, Misasa, Japan)

[SIT23-P14] Fate of water in subducted hydrous sediments deduced from stability fields of FeOOH and AlOOH up to 20 GPa

*Takashi Yoshino[1], Edward Baker[2], Kyle Duffey[3] (1.Institute for Planetary Materials, Okayama University, 2.Department of Earth Sciences, University of Oxford, 3.Department of Geosciences, Princeton University)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT23] Structure and Dynamics of Earth and Planetary Mantles

convener:Takashi Nakagawa(Department of Earth Sciences, The University of Hong Kong), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Dapeng Zhao(Department of Geophysics, Tohoku University), Chairperson:Takashi Yoshino(Okayama University)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SIT23-01] In search of recycled continental crust in the Mantle Transition Zone using geoneutrino measurements

*William F McDonough[1], Bedrich Roskovec[2], Ondrej Sramek[3] (1.Tohoku University, Sendai, Japan, 2.Universidad Catolica de Chile, Santiago, Chile, 3.Charles University, Praha 8, Czech Republic)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SIT23-02] Tectonic plates in 3D-numerical models of mantle convection with stress-history-dependent viscosity

*Takehiro Miyagoshi[1], Masanori Kameyama[2], Masaki Ogawa[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Ehime University, 3.University of Tokyo)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SIT23-03] Denoising S-Net Data to Image the Japan Trench: Comparisons to Alaska and Cascadia

*Claire Diane Doody[1,2], Qingkai Kong[1,2], William Scott[3], William Bythewood Hawley[1,2], Robert Martin-Short[1,2], Richard M Allen[1,2] (1.UC Berkeley, 2.Berkeley Seismo. Lab, 3.Imperial Coll. London)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SIT23-04] **Experimental confirmation of a spineloid transitional olivine polymorph using ultrafine-grained aggregates of Mg_2GeO_4**

*Thomas P. Ferrand[1], Takehiko Hiraga[1] (1.Earthquake Research Institute)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SIT23-05] Effects of fine-scale laminated heterogeneity on seismic anisotropy from long-period surface waves: Evaluation with two-dimensional waveform modelling

*Xu Yunao[1], Kazunori Yoshizawa[1,2], Takashi Furumura[3] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, Japan , 2.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, Japan, 3.Earthquake Research Institute, The University of Tokyo, Japan)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SIT23-06] **Redox kinetics of olivine revealed by diffusion profile of oxygen fugacity and its implication to the redox evolution of the uppermost mantle**

*Chengcheng Zhao[1], Takashi Yoshino[1] (1.Institute for Study of the Earth's Interior, Okayama University)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT23] Structure and Dynamics of Earth and Planetary Mantles

convener:Takashi Nakagawa(Department of Earth Sciences, The University of Hong Kong), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Dapeng Zhao(Department of Geophysics, Tohoku University), Chairperson:Dapeng Zhao(Tohoku University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SIT23-07] Reactive Melt Channelization in the Earth's Mantle

*Matej Pec[1], Benjamin Holtzman[3], Mark Zimmerman[2], David Kohlstedt[2] (1.Massachusetts Institute of Technology, 2.University of Minnesota, 3.Lamont-Doherty Earth Oservatory, Columbia University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SIT23-08] Deep structure and origin of the intraplate volcanoes in Northeast Asia

*Dapeng Zhao[1] (1.Department of Geophysics, Tohoku University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SIT23-09] 3D passive-source reverse-time migration imaging of mantle discontinuities

*Yang Shen[1], Jiahang Li[1], Hitoshi Kawakatsu[2] (1.Graduate School of Oceanography, University of Rhode Island, USA, 2.Earthquake Research Institute, University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SIT23-10] Configuration of slab beneath Ogasawara Islands and P-wave time differences between high and low frequencies

*Keiko Kuge[1] (1.Department of Geophysics, Graduate School of Science, Kyoto University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SIT23-11] Cool lower mantle transition zone inferred from seismic anisotropy of deformed ringwoodite

*Takaaki Kawazoe[1,2], Florian Heidelbach[2], Nobuyoshi Miyajima[2], Takayuki Ishii[2] (1.Hiroshima Univ., 2.Univ. Bayreuth)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SIT23-12] Crystal chemistry and compressibility of $Fe_{0.5}Mg_{0.5}Al_{0.5}Si_{0.5}O_3$ and $FeMg_{0.5}Si_{0.5}O_3$ silicate perovskites at pressures up to 95 GPa.

*Iuliia Koemets[1], Zhaodong Liu[2], Egor Gennadievich Koemets[1], Catherine McCammon[1], Artem Chanychev[1], Tomoo Katsura[1], Michael Hanfland[3], Aleksandr Chumakov[3] (1.Bayerisches Geoinstitut, Universitat Bayreuth, Bayreuth, Germany, 2.Jilin University, Changchun, China , 3.European Synchrotron Radiation Facility (ESRF), Grenoble Cedex, France.)

[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT24] Attenuation from crust to core: in situ experiments, observaions and implications

convener:Konishi Kensuke(Institute of Earth Sciences, Academia Sinica), Ikuo Katayama(Department of Earth and Planetary Systems Science, Hiroshima University), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Alexandre Schubnel(CNRS), Chairperson:Kensuke Konishi(Institute of Earth Sciences)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SIT24-01] Anomalous Vp/Vs Ratios at Seismic Frequencies Might Evidence Highly Damaged Rocks in Subduction Zones

*Alexandre Schubnel[1], Lucas Pimienta[2], Marie Violay[2], Jérome Fortin[1], Hélène Lyon-Caean[1] (1.Laboratoire de Géologie, ENS PARIS, 2.EPFL, Switzerland)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SIT24-02] Imaging crustal seismic attenuation, central Taupo Volcanic Zone, New Zealand

*Stephen C Bannister[1], Sandra Bourguignon[1], Ted Bertrand[1], Cameron Asher[1] (1.GNS Science)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SIT24-03] New Constraints on Seismological Structures of the Oceanic Asthenosphere

★Invited Papers

*Nozomu Takeuchi[1], Hitoshi Kawakatsu[1], Hajime Shiobara[1], Takehi Isse[1], Hiroko Sugioka[2], Aki Ito[3], Hisashi Utada[1] (1.Earthquake Research Institute, University of Tokyo, 2.Kobe University, 3.JAMSTEC)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SIT24-04] Frequency effects on elastic properties of saturated porous rocks: Experimental investigations

★Invited Papers

*Jerome Fortin[1] (1.Laboratoire de Géologie, Ecole Normale Superieure - Paris)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SIT24-05] Rock anelasticity due to grain boundary premelting

★Invited Papers

*Yasuko Takei[1], Hatsuki Yamauchi[1], Akihiro Tsunoda[1] (1.Earthquake Research Institute, University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SIT24-06] Experimental study of the effects of partial melting on anelasticity: toward quantitative interpretations of seismic high attenuation

*Hatsuki Yamauchi[1], Yasuko Takei[1] (1.Earthquake Research Institute, The University of Tokyo)

[E] Poster | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_17

[S-IT24] Attenuation from crust to core: in situ experiments, observaions and implications

convener:Konishi Kensuke(Institute of Earth Sciences, Academia Sinica), Ikuo Katayama(Department of Earth and Planetary Systems Science, Hiroshima University), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Alexandre Schubnel(CNRS)

[SIT24-P01] **Attenuation of seismic wave in water-saturated granite during triaxial deformation**

*Ikuo Katayama[1], Keiya Yamada[1], Kanta Zaima[1] (1.Department of Earth and Planetary Systems Science, Hiroshima University)

[SIT24-P02] Waveform inversion for the radial elastic and anelastic structure of the lowermost mantle beneath Central America and the Caribbean

*Anselme F. E. Borgeaud[1,2], Frederic Deschamps[1], Kensuke Konishi[1], Kenji Kawai[2], Robert J. Geller[2] (1.Institute of Earth Sciences, Academia Sinica, 2.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo)

[SIT24-P03] 3-D elastic and anelastic structure of the lowermost mantle beneath the western Pacific from finite-frequency tomography

*Konishi Kensuke[1], Nobuaki Fuji[2], Frederic Deschamps[1] (1.Institute of Earth Sciences, Academia Sinica, 2.Institut de Physique du Globe de Paris)

[SIT24-P04] **Inferring the lowermost mantle thermo-chemical structure beneath the Western Pacific with seismic attenuation and shear-wave speed anomalies**

*Frederic Deschamps[1], Kensuke Konishi[1], Nobuaki Fuji[2], Laura J Cobden[3] (1.Academia Sinica, 2.Institut de Physique du Globe de Paris, 3.Utrecht University)

[SIT24-P05] Intrinsic attenuation factor Q of partially molten Fe–S–O system

*Chao Liu[1], Takashi Yoshino[1] (1.Institute for Planetary Materials, Okayama University)

[SIT24-P06] Effect of pore pressure on attenuation of seismic waves in thermally cracked granite

*Keiya Yamada[1], Kazuki Sawayama[2], Ikuo Katayama[1] (1.Hiroshima University, 2.Kyushu University)

[E] Poster | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_30

[S-IT24] Attenuation from crust to core: in situ experiments, observaions and implications

convener:Konishi Kensuke(Institute of Earth Sciences, Academia Sinica), Ikuo Katayama(Department of Earth and Planetary Systems Science, Hiroshima University), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Alexandre Schubnel(CNRS)

[SIT24-P01] **Attenuation of seismic wave in water-saturated granite during triaxial deformation**

*Ikuo Katayama[1], Keiya Yamada[1], Kanta Zaima[1] (1.Department of Earth and Planetary Systems Science, Hiroshima University)

[SIT24-P02] Waveform inversion for the radial elastic and anelastic structure of the lowermost mantle beneath Central America and the Caribbean

*Anselme F. E. Borgeaud[1,2], Frederic Deschamps[1], Kensuke Konishi[1], Kenji Kawai[2], Robert J. Geller[2] (1.Institute of Earth Sciences, Academia Sinica, 2.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo)

[SIT24-P03] 3-D elastic and anelastic structure of the lowermost mantle beneath the western Pacific from finite-frequency tomography

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[SIT24-P04] **Inferring the lowermost mantle thermo-chemical structure beneath the Western Pacific with seismic attenuation and shear-wave speed anomalies**

*Frederic Deschamps[1], Kensuke Konishi[1], Nobuaki Fuji[2], Laura J Cobden[3] (1.Academia Sinica, 2.Institut de Physique du Globe de Paris, 3.Utrecht University)

[SIT24-P05] Intrinsic attenuation factor Q of partially molten Fe–S–O system

*Chao Liu[1], Takashi Yoshino[1] (1.Institute for Planetary Materials, Okayama University)

[SIT24-P06] Effect of pore pressure on attenuation of seismic waves in thermally cracked granite

*Keiya Yamada[1], Kazuki Sawayama[2], Ikuo Katayama[1] (1.Hiroshima University, 2.Kyushu University)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:Daisuke Miura, Nobuo Geshi(GSJ/AIST)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SVC36-01] The entire magmatic history of the Toba Caldera Complex that influenced human evolution, northern Sumatra, inferred from zircon U-Pb geochronology

*Hisatoshi Ito[1] (1.Central Research Institute of Electric Power Industry)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SVC36-02] Pre-eruptive magmatic processes of "Hakone Tokyo Pumice eruption"

*Ryo Tsujihara[1,2], Tetsu Kogiso[1], Takashi Sano[3], Hidemi Ishibashi[4] (1.Graduate School of Human and Environmental Studies, Kyoto University, 2.Asia Air Survey Co., Ltd., 3.National Museum of Nature and Science, 4.Faculty of Science, Shizuoka University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SVC36-03] Transition of magma plumbing system deduced from the melt inclusions contained in tephra minerals originated from Aso central cones.

*ryota nagaishi[1], Toshiaki Hasenaka[2], Masayuki Torii[2], ATSUSHI YASUDA[3], Natsumi Hokanishi[3] (1.Graduate of Science and Technology, Kumamoto University, 2.Center for water cycle, marin environment and disaster management , 3.Earthquake Reserach Institute, The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SVC36-04] Pre-eruptive magma dynamics of the climactic 110ka eruption of Toya caldera, Japan

*Akihiko Tomiya[1], Yoshihiko Goto[2], Tohru Danhara[3], Shanaka L de Silva[4] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Muroran Institute of Technology, 3.Kyoto Fission-Track Co., Ltd., 4.Oregon State University, College of Earth, Ocean and Atmospheric Sciences)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SVC36-05] Voluminous silicic magma formation for the 30 ka Aira catastrophic caldera-forming eruption: contributions of crust-derived mafic and felsic magmas

*Ayumu Nishihara[1], Yoshiyuki Tatsumi[2,1], Keiko Suzuki-Kamata[2,1], Katsuya Kaneko[1,2], Jun-Ichi Kimura[3], Qing Chang[3], Hironobu Hinata[4], Takashi Miyazaki[3], Bogdan Stefanov Vaglarov[3] (1.Department of Planetology, Graduate School of Science , Kobe University, 2.Kobe Ocean-Bottom Exploration Center, 3.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology, 4.Kobe Municipal Tarumi Junior High School)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SVC36-06] Stratigraphy and petrological relations of pre-Aso volcanic rocks in Tateno district, Minami-Aso village

*Shota Togawa[1], Toshiaki Hasenaka[2], Masayuki Torii[2], Yasushi Mori[3] (1.Graduate school of science and technology, 2.Center for Water Cycle, Marine Environment and Disaster management, Kumamoto University, 3.Kitakyushu Museum of Natural History and Human History)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:Nobuo Geshi(GSJ/AIST), Daisuke Miura

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SVC36-07] Caldera structure delineated by airborne gravity gradiometry

*Atusi NINOMIYA[1], Hiromasa ISHIKAWA[1], Shunsuke NOGAMI[1], Yoshio NAKASATO[1] (1.Sumiko Resources Exploration and Development Co., Ltd.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SVC36-08] The initial fine ash deposit of the Shikotsu caldera-forming eruption at ca. 45 ka

*Chiharu Tomijima[1], Daisuke MIURA[1], Shimpei Uesawa[2], Mizuho Amma-Miyasaka[3] (1.Department of Physical Science, Graduate School of Science, Osaka Prefecture University, 2.Central Research Institute of Electric Power Industry, 3.Graduate School of Sciences, Hokkaido University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SVC36-09] Characterization of the Small-volume Pyroclastic Flows from the Kuchinoerabu-jima Volcano during 2018-2019, Southwest Japan

*Ryuta FURUKAWA[1], Teruki Oikawa[1], Nobuo Geshi[1] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SVC36-10] An explanation of size and position of Mt. Fuji

*Yasushi Harada[1], Miyu Takahashi[1] (1.School of Marine Science and Technology, Tokai University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SVC36-11] Arc magmatism in the northernmost part of Kamchatka caused by the aseismic subducted Bering slab

*Tatsuji Nishizawa[1], Hitomi Nakamura[2,3,4,5], Tatiana Churikova[6,7], Boris Gordeychik[6,8], Maria Pevzner[9], Osamu Ishizuka[2,10], Hikaru Iwamori[3,4,11] (1.Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 2.Institute of Earthquake and Volcano Geology, Geological Survey of Japan, AIST, 3.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology, 4.Depeartment of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 5.ORCeNG, Chiba Institute of Technology, 6.GZG, Abt. Geochemie, Universität Göttingen, 7.Institute of Volcanology and Seismology, Far East Branch, Russian Academy of Sciences, 8.Institute of Experimental Mineralogy, Russian Academy of Sciences, 9.Geological Institute, Russian Academy of Sciences, 10.R & D Center for Ocean Drilling Science, Japan Agency for Marine-Earth Science and Technology, 11.Earthquake Research Institute, The University of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SVC36-12] Redox state of magma in the deep crust beneath NE Japan arc: constraints from cumulate xenoliths from Ichinomegata Maar

*Naoya Tsushima[1], Michihiko Nakamura[1], Yasuhiro Yanagida, Takeyoshi Yoshida[1] (1.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University)

[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:RYUTA FURUKAWA, Teruki Oikawa

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SVC36-13] Deformation of a rhyolite lava below the Curie temperature: the Sanukayam lava in Kouzusima Island, Japan

*Takuma Kamio[1], Kuniyuki Furukawa[2], Tatsuo Kanamaru[3], Koji Uno[1] (1.Okayama University, 2.Aichi University, 3.Nihon University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SVC36-14] Evolution of magmatic chemistry for the Asama-Maekake volcano since 10ka revealed by whole-rock chemical analysis of pumice obtained by the trenching of air-fall tephra deposits

*Masaki Takahashi[1], Maya Yasui[1], Tatsuo Kanamaru[1] (1.Department of Earth and Environmental Sciences, College of Humanities and Sciences, Nihon University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SVC36-15] Late Pleistocene–Holocene tephra ejecta in the trench log at the southern apron of Esan volcanic complex, Japan

*Daisuke MIURA[1], Ryuta FURUKAWA[2], Kenichi Arai[3] (1.Graduate School of Science, Osaka Prefecture University, 2.Institute of Earthquake and Volcano Geology, GSJ/AIST, 3.Asia Air Survey)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SVC36-16] **Transition of eruption sequence and magma plumbing system at the 1.4 ka Nakamachineshiri eruption of Me-Akandake volcano, eastern Hokkaido, Japan.**

*Kosuke Ishige[1,2], Mitsuhiro Nakagawa[1] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2.Mitsubishi Materials Corporation)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SVC36-17] Kilo-year-evolution of magma plumbing system with dominant modes of eruption at Suwanosejima volcano, Southwest Japan

*Taketo Shimano[1], ATSUSHI YASUDA[2] (1.Graduate School of Environment and Disaster Research, Tokoha University, 2.Earthquake Research Institute, University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SVC36-18] Temporal variation of the magma compositions of the Miyakejima volcano during the last 2700 years

*Nobuo Geshi[1], Teruki Oikawa[1] (1.Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology)

[J] Poster | S (Solid Earth Sciences)：S-VC Volcanology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_18

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology)

[SVC36-P01] Reinvestigation of the eruptive history of Me-akan volcano, eastern Hokkaido, using trench survey

*Eiichi Sato[1], Keiji Wada[2], Yusuke Minami[3], Yoshihiro Ishizuka[3], Mitsuhiro Nakagawa[4], Yoshiko Adachi[4] (1.Institute for Promotion of Higher Education, Kobe University, 2.Earth Science Laboratory, Hokkaido University of Education at Asahikawa, 3.Geological Survey of Japan, AIST, 4.Department of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University)

[SVC36-P02] Eruptive history at Ponmachineshiri in Meakan volcano during the last 1000 years: Implication from trench surveys

*Yusuke Minami[1], Mitsuhiro Nakagawa[2], Eiichi Sato[3], Keiji Wada[4], Yoshihiro Ishizuka[1], Yoshiko Adachi[2] (1.Geological Survey of Japan, AIST, 2.Department of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University, 3.Institute for Promotion of Higher Education, Kobe University, 4.Earth Science Laboratory, Hokkaido University of Education at Asahikawa)

[SVC36-P03] **Transition of magma plumbing system during the past 14 thousand years of Mashu volcano, eastern Hokkaido**

*Keiji Wada[1], Eiichi Sato[2], Kyohei Sano[3], Yuya Okada[1] (1.Earth Science Laboratory, Hokkaido University of Education at Asahikawa, 2.Institute for Promotion of Higher Education, Kobe University, 3.Shirataki-Geopark)

[SVC36-P04] Eruption sequence of 7.6 ka caldera-forming eruption from Mashu-volcano eastern Hokkaido, japan

*Shibata Shohei[1], Takeshi Hasegawa[1] (1.Department of Earth Sciences, College of Science, Ibarbki University)

[SVC36-P05] Geological study of the 1000 yBP Ma-b eruption, Mashu volcano, eastern Hokkaido: Especially for the change of eruption style.

*Kenta Ueno[1], Mitsuhiro Nakagawa[1] (1.Depatment of Natural History of Sciences, Graduate School of Science, Hokkido University)

[SVC36-P06] Petrology of the caldera-forming eruption of Nigorikawa Caldera, Southwest Hokkaido, Japan

*Yasuaki Kaenda[1], Takeshi Hasegawa[1] (1.University of Ibaraki)

[SVC36-P07] Textual analyses for pumice from precursory Plinian eruption of Aira caldera forming eruption

*Miki Ogata[1], Atsushi Toramaru[2] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University)

[SVC36-P08] Long-term input rate of mafic magma inferred from a long-term heat balance model of silicic magma reservoir

*Shimpei Uesawa[1] (1.Central Research Institute of Electric Power Industry)

[SVC36-P09] Outgassing and Oxidation processes of viscous magmas inferred from micro-Raman and IR spectroscopy

*Kyohei Sano[1], Eiichi Sato[2], Keiji Wada[3], Motohiro Tsuboi[4], Reina NAKAOKA[5] (1.Shirataki-Geopark, 2.Kobe University Institute for Promotion of Higher Education, 3.Hokkaido University of Education at Asahikawa, 4.School of Science and Technology, Kwansei Gakuin University, 5.Kobe Ocean-Bottom Exploration Center, Kobe University)

[SVC36-P10] Distribution of ballistic blocks during the 2014 eruption of Ontake Volcano, central Japan

*Teruki Oikawa[1], Mitsuhiro Yoshimoto[2], Yoshihiro Takeshita[3], Fukashi Maeno[4], Jiro Komori[5], Setsuya Nakada[9], Taketo Shimano[10], Hisashi Sasaki[6], Kishimoto Hiroshi[6], Tatsuro Chiba[6], Yasuhiro Ishimine[7], Kae Tsunematsu[8], Yoshihiro Ishizuka[1] (1.GSJ, National Institute of Advanced Industrial Science and Technology , 2.Mt. Fuji Reserch Institute,

Yamanashi Prifectural Goverment, 3.Faculty of Education, Shinshu University, 4.Earthquake Reserch Institute, University of Tokyo, 5.Teikyo Heisei University, 6.Asia Air Survey Co., Ltd., 7.Reserch and Education Center for Natural Hazards, Kagoshima University, 8.Yamagata University, 9.National Reserch Insitute for Earth Science and Disaster Resilience, 10.Graduate School of Environment and Disaearch, Tokoha University)

[SVC36-P11] After 2014 eruption, The volcanic crustal deformation around Mt. Ontake

*Haruno Koike[1], Takeo Ito[2], Kenjiro Matsuhiro[2], Shinichiro Horikawa[2], Takashi OKUDA[2], Takahiro Kunitomo[2], kazushi tanoue[2], Yuto Iwase[1], Koki Kumagai[1] (1.Graduate School of Environmental Studies, Nagoya University, 2.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University)

[SVC36-P12] Geological and petrological study of Kariba volcanic group: Elucidation of the volcanic history and changes of magma

*Shota Taji[1], Mitsuhiro Nakagawa[2] (1.Graduate School of Science, Hokkaido University, 2.Faculty of Science, Hokkaido University)

[SVC36-P13] Stratigraphy and evolutionary mechanism for the low-K tholeiitic magmas at Kotakakura volcano in the Sengan geothermal field, Northeast Japan arc

*Goto Yoshiaki[1], Akihiko Fujinawa[2] (1.Graduate school of Science and Engineering, Ibaraki University, 2.Faculty of Science, Ibaraki University)

[SVC36-P14] Pre-eruptive magmatic processes of upper part of Goshikidake pyroclastic rocks, Zao volcano

*Motohiro Sato[1], Masao Ban[1] (1.Graduate School of Science and Technology, Yamagata University)

[SVC36-P15] Geology and petrology of Futamata volcano, Nasu volcano group, NE Japan

*Shota Watanabe[1], Takeshi Hasegawa[1] (1.Ibaraki Univ.)

[SVC36-P16] Magma of the Haruna-Caldera forming eruption in view of Shirakawa pyroclastic flow deposits-

*Goro Kitani[1], Yuki Suzuki[2], Masayuki Oishi[3] (1.Department of Earth Sciences, School of Education , Waseda University, 2.Department of Earth Sciences, Faculty of Education and Integrated Arts of Sciences, Waseda University, 3.Sendai Regional Headquarters, Japan Meteorological Agency)

[SVC36-P17] Magma plumbing system in the caldera-forming eruption of Haruna volcano indicated by Satomi pyroclastic flow deposit

*Momoka Okano[1], Yuki Suzuki[2] (1.Department of Earth Sciences, School of Education, Waseda University, 2.Department of Earth Sciences, Faculty of Education and Integrated Arts of Sciences, Waseda University)

[SVC36-P18] Petrology of the Minamiryu-ga-banba in Hakusan Volcano

*Taichiro Miyashita[1], Susumu Umino[1], Yuzuki Ibaraki[2] (1.Kanazawa University, 2.Chuken Consultant Co., Ltd)

[SVC36-P19] Tephrochronological relations of Middle-Pleistocene tephra derived from Myoko Volcanic Group and the pumice and scoria fall deposits found in Kosha Volcano, Central Japan

*Naoaki TAKASUGI[1], Takeshi Saito[1], Kuniaki Makino[1], Takehiko Suzuki[2] (1.Shinshu University, 2.Tokyo Metropolitan University)

[SVC36-P20] Geologic and petrologic study of the Kamo monogenetic volcanic field,Southern Kyushu,Japan

*Linus Anye Nche[1], Takeshi - Hasegawa[1], Tetsuo - Kobayashi[2], Károly - Németh[3], Festus Tongwa Aka[4] (1. Ibaraki Univ., 2.Kagoshima Univ., 3. Massey Univ., 4.IRGM)

[SVC36-P21] **Investigation on Lava Tube Caves in Manno lava flow of Mt.Fuji**

*Tsutomu Honda[1] (1.Vulcano-speleological Society)

[J] Poster | S (Solid Earth Sciences)：S-VC Volcanology

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_31

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology)

[SVC36-P01] Reinvestigation of the eruptive history of Me-akan volcano, eastern Hokkaido, using trench survey

*Eiichi Sato[1], Keiji Wada[2], Yusuke Minami[3], Yoshihiro Ishizuka[3], Mitsuhiro Nakagawa[4], Yoshiko Adachi[4] (1.Institute for Promotion of Higher Education, Kobe University, 2.Earth Science Laboratory, Hokkaido University of Education at Asahikawa, 3.Geological Survey of Japan, AIST, 4.Department of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University)

[SVC36-P02] Eruptive history at Ponmachineshiri in Meakan volcano during the last 1000 years: Implication from trench surveys

*Yusuke Minami[1], Mitsuhiro Nakagawa[2], Eiichi Sato[3], Keiji Wada[4], Yoshihiro Ishizuka[1], Yoshiko Adachi[2] (1.Geological Survey of Japan, AIST, 2.Department of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University, 3.Institute for Promotion of Higher Education, Kobe University, 4.Earth Science Laboratory, Hokkaido University of Education at Asahikawa)

[SVC36-P03] **Transition of magma plumbing system during the past 14 thousand years of Mashu volcano, eastern Hokkaido**

*Keiji Wada[1], Eiichi Sato[2], Kyohei Sano[3], Yuya Okada[1] (1.Earth Science Laboratory, Hokkaido University of Education at Asahikawa, 2.Institute for Promotion of Higher Education, Kobe University, 3.Shirataki-Geopark)

[SVC36-P04] Eruption sequence of 7.6 ka caldera-forming eruption from Mashu-volcano eastern Hokkaido, japan

*Shibata Shohei[1], Takeshi Hasegawa[1] (1.Department of Earth Sciences, College of Science, Ibarbki University)

[SVC36-P05] Geological study of the 1000 yBP Ma-b eruption, Mashu volcano, eastern Hokkaido: Especially for the change of eruption style.

*Kenta Ueno[1], Mitsuhiro Nakagawa[1] (1.Depatment of Natural History of Sciences, Graduate School of Science, Hokkido University)

[SVC36-P06] Petrology of the caldera-forming eruption of Nigorikawa Caldera, Southwest Hokkaido, Japan

*Yasuaki Kaenda[1], Takeshi Hasegawa[1] (1.University of Ibaraki)

[SVC36-P07] Textual analyses for pumice from precursory Plinian eruption of Aira caldera forming eruption

*Miki Ogata[1], Atsushi Toramaru[2] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University)

[SVC36-P08] Long-term input rate of mafic magma inferred from a long-term heat balance model of silicic magma reservoir

*Shimpei Uesawa[1] (1.Central Research Institute of Electric Power Industry)

[SVC36-P09] Outgassing and Oxidation processes of viscous magmas inferred from micro-Raman and IR spectroscopy

*Kyohei Sano[1], Eiichi Sato[2], Keiji Wada[3], Motohiro Tsuboi[4], Reina NAKAOKA[5] (1.Shirataki-Geopark, 2.Kobe University Institute for Promotion of Higher Education, 3.Hokkaido University of Education at Asahikawa, 4.School of Science and Technology, Kwansei Gakuin University, 5.Kobe Ocean-Bottom Exploration Center, Kobe University)

[SVC36-P10] Distribution of ballistic blocks during the 2014 eruption of Ontake Volcano, central Japan

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Yamanashi Prifectural Goverment, 3.Faculty of Education, Shinshu University, 4.Earthquake Reserch Institute, University of Tokyo, 5.Teikyo Heisei University, 6.Asia Air Survey Co., Ltd., 7.Reserch and Education Center for Natural Hazards, Kagoshima University, 8.Yamagata University, 9.National Reserch Insitute for Earth Science and Disaster Resilience, 10.Graduate School of Environment and Disaearch, Tokoha University)

[SVC36-P11] After 2014 eruption, The volcanic crustal deformation around Mt. Ontake

*Haruno Koike[1], Takeo Ito[2], Kenjiro Matsuhiro[2], Shinichiro Horikawa[2], Takashi OKUDA[2], Takahiro Kunitomo[2], kazushi tanoue[2], Yuto Iwase[1], Koki Kumagai[1] (1.Graduate School of Environmental Studies, Nagoya University, 2.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University)

[SVC36-P12] Geological and petrological study of Kariba volcanic group: Elucidation of the volcanic history and changes of magma

*Shota Taji[1], Mitsuhiro Nakagawa[2] (1.Graduate School of Science, Hokkaido University, 2.Faculty of Science, Hokkaido University)

[SVC36-P13] Stratigraphy and evolutionary mechanism for the low-K tholeiitic magmas at Kotakakura volcano in the Sengan geothermal field, Northeast Japan arc

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[SVC36-P14] Pre-eruptive magmatic processes of upper part of Goshikidake pyroclastic rocks, Zao volcano

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[SVC36-P15] Geology and petrology of Futamata volcano, Nasu volcano group, NE Japan

*Shota Watanabe[1], Takeshi Hasegawa[1] (1.Ibaraki Univ.)

[SVC36-P16] Magma of the Haruna-Caldera forming eruption in view of Shirakawa pyroclastic flow deposits-

*Goro Kitani[1], Yuki Suzuki[2], Masayuki Oishi[3] (1.Department of Earth Sciences, School of Education , Waseda University, 2.Department of Earth Sciences, Faculty of Education and Integrated Arts of Sciences, Waseda University, 3.Sendai Regional Headquarters, Japan Meteorological Agency)

[SVC36-P17] Magma plumbing system in the caldera-forming eruption of Haruna volcano indicated by Satomi pyroclastic flow deposit

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[SVC36-P18] Petrology of the Minamiryu-ga-banba in Hakusan Volcano

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[SVC36-P19] Tephrochronological relations of Middle-Pleistocene tephra derived from Myoko Volcanic Group and the pumice and scoria fall deposits found in Kosha Volcano, Central Japan

*Naoaki TAKASUGI[1], Takeshi Saito[1], Kuniaki Makino[1], Takehiko Suzuki[2] (1.Shinshu University, 2.Tokyo Metropolitan University)

[SVC36-P20] Geologic and petrologic study of the Kamo monogenetic volcanic field,Southern Kyushu,Japan

*Linus Anye Nche[1], Takeshi - Hasegawa[1], Tetsuo - Kobayashi[2], Károly - Németh[3], Festus Tongwa Aka[4] (1. Ibaraki Univ., 2.Kagoshima Univ., 3. Massey Univ., 4.IRGM)

[SVC36-P21] **Investigation on Lava Tube Caves in Manno lava flow of Mt.Fuji**

*Tsutomu Honda[1] (1.Vulcano-speleological Society)

[E] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[S-TT42] Recent Advances in Exploration Geophysics 2019

convener:Hitoshi Mikada(Kyoto University), Yoshihisa Iio(Disater Prevention Research Institute, Kyoto University), Nobukazu Seama(Department of Planetology, Graduate School of Science, Kobe University), Junichi Takekawa(Graduate School of Science, Kyoto University), Chairperson:Yusuke Watanabe(Graduate School of Engineering, Kyoto University), Junichi Takekawa(Graduate School of Engineering, Kyoto University)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[STT42-01] Numerical modeling of the effect of borehole stress concentration on sonic logging measurements in shale formations

*Shimin - Zhou[1], Xinding - Fang[1] (1.Southern University of Science and Technology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[STT42-02] Fundamental study on hydraulic fracturing simulation with DEM under high pressure and temperature condition

*Hayate Ohtani[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.kyoto university)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[STT42-03] A fundamental study of proppant behavior in hydraulic fractures using particle based numerical simulations

★Invited Papers

*Junichi Takekawa[1], Hitoshi Mikada[1] (1.Graduate School of Science, Kyoto University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[STT42-04] Monitoring of mass density variation inside active volcanoes with cosmic-ray muography

*Laszlo Olah[1], Hiroyuki K. M. Tanaka[1], Gergo Hamar[2], Dezso Varga[2] (1.Earthquake Research Institute, The University of Tokyo, 2.Wigner Research Centre for Physics of the Hungarian Academy of Sciences)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[STT42-05] New development and operation of the EM-ACROSS: an investigation at Mount Kusatsu-Shirane

★Invited Papers

*Kuo Hsuan Tseng[1], Yasuo Ogawa[1], Takahiro Kunitomo[3], Masato Fukai[1], Hiroshi Ichihara[2] (1.Earth and Planetary science, Tokyo Institute of Technology, 2.Graduate School of Environmental Studies, Nagoya University, 3.Nagoya University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[STT42-06] A feasibility study to identify supercritical geothermal reservoirs on southern Kyushu Island using DTS and DAS systems

★Invited Papers

*Junzo Kasahara[1,5], Yoko Hasada[2,1], Hiroyasu Kuzume[1], Fujise Yoshihiro[4,1], Hitoshi Mikada[3] (1.ENAA, 2.Daiwa Exploration and Consulting Co., 3.Kyoto Univ., 4.WELMA Co. Ltd., 5.Shizuoka Univ.)

[E] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[S-TT42] Recent Advances in Exploration Geophysics 2019

convener:Hitoshi Mikada(Kyoto University), Yoshihisa Iio(Disater Prevention Research Institute, Kyoto University), Nobukazu Seama(Department of Planetology, Graduate School of Science, Kobe University), Junichi Takekawa(Graduate School of Science, Kyoto University), Chairperson:Junichi Takekawa(Graduate School of Engineering, Kyoto University), Yusuke Watanabe(Graduate School of Engineering, Kyoto University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[STT42-07] The observation of active source and ambient noise signals with telecommunication fiber-optic cable in urban area

*Baoshan Wang[1], Xiangfang Zeng[2], Xiaobin Li[3], Weiwei Xu[4], Shanhui Xu[4], Zhenghong Song[1] (1.School of Earth and Space Sciences, University of Science and Technology of China, 2.State Key Laboratory of Geodesy and Earth's Dynamics, Institute of Geodesy and Geophysics, Chinese Academy of Sciences, 3.Earthquake Agency of Yunnan Province, 4.Institute of Geophysics, China Earthquake Administration)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[STT42-08] Comparison of RTM results of time-lapse imaging in foam-assisted EOR

*Rei Tamura[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[STT42-09] The estimation of physical properties of buried targets using the Cole-Cole equation in fictitious wave domain method

*Kohshi Kimura[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[STT42-10] Numerical investigation of permeability anisotropy in porous media using a particle method

*Ryo Masumura[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[STT42-11] **Numerical Description of Flow Channel in Pipe Conduits Considering Solid-fluid Phase Shift with Lattice Boltzmann Method**

*Masaki Iwata[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[STT42-12] Evaluation of anisotropic parameters using virtual cross-dipole data with full waveform approach

*YUSUKE WATANABE[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto Univesity)

[E] Poster | S (Solid Earth Sciences)：S-TT Technology & Techniques

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_19

[S-TT42] Recent Advances in Exploration Geophysics 2019

convener:Hitoshi Mikada(Kyoto University), Yoshihisa Iio(Disater Prevention Research Institute, Kyoto University), Nobukazu Seama(Department of Planetology, Graduate School of Science, Kobe University), Junichi Takekawa(Graduate School of Science, Kyoto University)

[STT42-P01] DISCRIMINATION OF HYDRATE BEARING MARINE SEDIMENTS BY USING FREQUENCY BASED ATTENUATION

*Nisar Ahmed[1], Mubasher Ahmad[1], Perveiz Khalid[1] (1.Institute of Geology, University of the Punjab, Lahore 54590, Pakistan)

[STT42-P02] Evaluation of methane hydrate based on attenuation parameter in seismic exploration

*Mizuki Kawabe[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto Unibercity)

[STT42-P03] Estimating the earthquake source mechanism using full waveform inversion

*Jang Iktae[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

[STT42-P04] A quantitative analysis of the passive seismic emission tomography using the lattice Boltzmann method

*Sakemi Yuichi[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

[STT42-P05] A feasibility study for supercritical geothermal energy in enhanced geothermal system

*Tatsuki Ueda[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

[E] Poster | S (Solid Earth Sciences)：S-TT Technology & Techniques

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_32

[S-TT42] Recent Advances in Exploration Geophysics 2019

convener:Hitoshi Mikada(Kyoto University), Yoshihisa Iio(Disater Prevention Research Institute, Kyoto University), Nobukazu Seama(Department of Planetology, Graduate School of Science, Kobe University), Junichi Takekawa(Graduate School of Science, Kyoto University)

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*Tatsuki Ueda[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-TT44] Airborne surveys and monitoring of the Earth

convener:Shigekazu Kusumoto(Graduate School of Science and Engineering for Research, University of Toyama), Takao Koyama(Earthquake Research Institute, University of Tokyo), Yuji Mitsuhata(AdvancedIndustrial Science and Technology), Shigeo Okuma(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Chairperson:Shigekazu Kusumoto, Takao Koyama(東京大学 地震研究所 火山センター), Shigeo Okuma(産業技術総合研究所), Yuji Mitsuhata(国立研究開発法人　産業技術総合研究所)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[STT44-01] A Case Study on the Application of a Magnetic Survey Using Magnetometers Carried by Multicopter-type Drones

★Invited Papers

*Shiga Nobuhiko[1], Harada Haruo[1], Wada Kazushige[1] (1.Mitsui Mineral Development Engineering Co., Ltd.)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[STT44-02] Development for upgrading the generalization capability of the seismic damage detection of building based on the deep-learning utilizing aerial photographs

★Invited Papers

*Shohei Naito[1], Hiromitsu Tomozawa[2], Yuji Mori[2], Naokazu Monma[3], Hiromitsu Nakamura[1], Hiroyuki Fujiwara[1] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Mizuho Information and Research Institute, Inc., 3.Pasco Corporation)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[STT44-03] The resistivity distribution under the ground on bedrock creep slopes in Kii mountain area by the airborne electromagnetic survey

*Atsuhiko Kinoshita[1,2], Yasutaka Tanaka[2], Wataru Sakurai[1], Taro Uchida[1], Koichiro Hayashi[3], Katsushi Kawato[4], Minoru Okumura[4] (1.National Institute for Land and Infrastructure Management, 2.Sediment Disaster Prevention Technology Center, Kinki Developing Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism , 3.OYO Corporation, 4.NIPPON ENGINEERING CONSULTANTS CO.,LTD.)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[STT44-04] Study of UAV photogrammetry toward efficiently grasping volcanic landform

*Yuichi Iwasa[1], Takeshi Matsushima[2] (1.department of earth and planetary sciences, graduate school of sciences, Kyushu University, 2.SEVO, Kyushu Univ.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[STT44-05] Volcanic gas measurements using UAVs

*Takeshi Hashimoto[1], Akihiko Terada[2], Toshiya Mori[3], Ryo Tanaka[1] (1.Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University, 2.Volcanic Fluid Research Center, Tokyo Institute of Technology, 3.Geochemical Research Center, Graduate School of Science, The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[STT44-06] Repeated Drone Magnetic Survey over Usu Volcano, Hokkaido Japan

*Shigeo Okuma[1], Masahiko Makino[2], Tadashi Nakatsuka[1], Ayumu Miyakawa[1], Makoto Yanagida[3], Minoru Okumura[4] (1.Institute of Geology and Geoinformation, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 3.Hanshin Consultants Co., Ltd., 4.Nippon Engineering Consultants Co., Ltd.)

[J] Poster | S (Solid Earth Sciences)：S-TT Technology & Techniques

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_33

[S-TT44] Airborne surveys and monitoring of the Earth

convener:Shigekazu Kusumoto(Graduate School of Science and Engineering for Research, University of Toyama), Takao Koyama(Earthquake Research Institute, University of Tokyo), Yuji Mitsuhata(AdvancedIndustrial Science and Technology), Shigeo Okuma(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST))

[STT44-P01] Development of an optical remote sensing technique for volcanic surface phenomena observation to estimate hyperspectral data from multispectral data

*Tetsuya Jitsufuchi[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[STT44-P02] Geomagnetic total intensity change before and after the eruptions at Shinmoedake volcano in 2018 detected by aeromagnetic surveys

*Takao Koyama[1], Takayuki Kaneko[1], Takao Ohminato[1], Atsushi Watanabe[1], Fukashi Maeno[1] (1.Earthquake Research Institute, University of Tokyo)

[STT44-P03] Droneborne resistivity mapping for a shallow ground investigation

*Yuji Mitsuhata[1], Tishiyuki Yokota[1] (1.AdvancedIndustrial Science and Technology)

[STT44-P04] Improvement test and field application applicability of airborne electromagnetic survey using drone

*Youichi Yuuki[1], Akira Jomori[2], Atsuyoshi Jomori[2], Takashi Kondoh[2] (1.Oyo corporation, 2.NEOSCIENCE)

[STT44-P05] Special Techniques for Airborne Laser Scanning Using Unmanned Helicopters

*Tomoya Hayakawa[1], Mio Kasai[2], Junro Imai[3], Akihiko Tani[4], Takatoshi Mikami[4] (1.NIPPON KOEI CO., LTD., 2.Hokkaido University Institute of Earth Surface Processes and Land Management, 3.YAMAHA MOTORCYCLE CO., LTD., 4.Obihiro Development and Construction Dept., Hokkaido Regional Development Bureau)

[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 304 3F

[S-TT47] Creating future of solid Earth science with high performance computing (HPC)

convener:Takane Hori(R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology), Yuji Yagi(Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba), Katsuhiko Shiomi(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Takane Hori

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[STT47-01] Expectations to more realistic Green's function with modeling errorfor the real-time estimation of the coseismic fault model

*Yusaku Ohta[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[STT47-02] Development of high-performance low order unstructured implicit finite-element solvers for solid earth science problems

★Invited Papers

*Kohei Fujita[1], Tsuyoshi Ichimura[1], Takuma Yamaguchi[1] (1.Earthquake Research Institute, The University of Tokyo)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[STT47-03] Optimal spectral element method for elastic wave computation

*Kei Hasegawa[1], Nobuaki Fuji[2], Kensuke Konishi[3] (1.Earthquake Research Institute, University of Tokyo, 2.Institut de Physique du Globe de Paris, 3.Institute of Earth Sciences, Academia Sinica)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[STT47-04] Multi scale tsunami simulation from earthquake initiation to tsunami run-up into the coastal area and high performance particle simulator

*Mitsuteru Asai[1], Mikito Furuichi[2], Daisuke Nishiura[2] (1.Kyushu University, 2.JAMSTEC)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[STT47-05] Digital-Ensemble Concept for Making Resilient Society against Natural Hazard

*Satoru Oishi[1] (1.RIKEN Center for Computational Science)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[STT47-06] Expected Role of High Performance Computing to Promote Earthquake Research

★Invited Papers

*Naoshi Hirata[1] (1.Earthquake Research Institute, the University of Tokyo)

[J] Poster | S (Solid Earth Sciences)：S-TT Technology & Techniques

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_20

[S-TT47] Creating future of solid Earth science with high performance computing (HPC)

convener:Takane Hori(R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology), Yuji Yagi(Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba), Katsuhiko Shiomi(National Research Institute for Earth Science and Disaster Resilience)

[STT47-P01] Prototype of Green's function library for geodetic slip inversion based on an integrated velocity structure model of Japan

*Ryoichiro Agata[1], Tsuyoshi Ichimura[2,3,4], Kohei Fujita[2,3], Takuma Yamaguchi[2], Takeshi Iinuma[1], Takane Hori[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, The University of Tokyo, 3.Center for Computational Science, RIKEN, 4.Center for Advanced Intelligence Project, RIKEN)

[STT47-P02] The Smoothed Particle Hydrodynamics on modern architectures

*Natsuki Hosono[1,2], Mikito Furuichi[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.RIKEN Center for Computational Science)

[STT47-P03] Development of Monitoring and Forecasting Methods for Crustal Activity Utilizing Large-Scale High-Fidelity Finite Element Simulations with 3D Heterogeneous Medium

*Takane Hori[1], Tsuyoshi Ichimura[2], Kohei Fujita[2], Takuma Yamaguchi[2], Ryoichiro Agata[1], Takeshi Iinuma[1] (1.R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, The University of Tokyo)

[J] Poster | S (Solid Earth Sciences)：S-TT Technology & Techniques

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_34

[S-TT47] Creating future of solid Earth science with high performance computing (HPC)

convener:Takane Hori(R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology), Yuji Yagi(Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba), Katsuhiko Shiomi(National Research Institute for Earth Science and Disaster Resilience)

[STT47-P01] Prototype of Green's function library for geodetic slip inversion based on an integrated velocity structure model of Japan

*Ryoichiro Agata[1], Tsuyoshi Ichimura[2,3,4], Kohei Fujita[2,3], Takuma Yamaguchi[2], Takeshi Iinuma[1], Takane Hori[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, The University of Tokyo, 3.Center for Computational Science, RIKEN, 4.Center for Advanced Intelligence Project, RIKEN)

[STT47-P02] The Smoothed Particle Hydrodynamics on modern architectures

*Natsuki Hosono[1,2], Mikito Furuichi[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.RIKEN Center for Computational Science)

[STT47-P03] Development of Monitoring and Forecasting Methods for Crustal Activity Utilizing Large-Scale High-Fidelity Finite Element Simulations with 3D Heterogeneous Medium

*Takane Hori[1], Tsuyoshi Ichimura[2], Kohei Fujita[2], Takuma Yamaguchi[2], Ryoichiro Agata[1], Takeshi Iinuma[1] (1.R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, The University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:shuhei Totsuka, Ayanori Misawa

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG56-01] The restoration of precipitation record of iron hydroxide about seven years in Nagahama Bay, Satsuma Iwo-jima, Kagoshima.

*Naoya Sakamoto[1], Shoichi Kiyokawa[2] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SCG56-02] Mineralogical and geochemical study of hydrothermal deposits beneath the seafloor at the Gondou field in the Okinawa Trough

*Shuhei Totsuka[1], Jun-ichiro Ishibashi[2], Kazuhiko Shimada[2], Kei Ikehata[3], Hideaki Machiyama[4], Koichi Iijima[4], Hirofumi Yamamoto[4], Hidenori Kumagai[4], Ken Ikehara[5], Toru Yamasaki[5], Yutaro Takaya[6], Toshiro Nagase[7], Thomas Tindell[8], Kotaro Yonezu[8], Yuki Tada[8] (1.Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 3.Faculty of Life and Environmental Sciences, University of Tsukuba, 4.Research and Development Center for Submarine Resources, JAMSTEC, 5.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 6.Department of Resources and Environmental Engineering School of Creative Science and Enginerring, Waseda University, 7.Tohoku University Museum, 8.Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG56-03] Strontium isotope study of sulfate minerals obtained by scientific drilling from seafloor hydrothermal fields in the Okinawa Trough

Akihi Tsutsumi[1], Naru Tsukamoto[1], Kazuhiko Shimada[1], *Jun-ichiro Ishibashi[1], Ryuichi Shinjo[2] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Faculty of Science, University of Ryukyus)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG56-04] Numerical modeling of seafloor hydrothermal system in the Izena Caldron, Okinawa Trough

*Shohei Albert Tomita[1], Katsuaki Koike[1], Tada-nori Goto[1], Katsuhiko Suzuki[2], Takafumi Kasaya[2] (1.Graduate School of Engineering, Kyoto University, 2. Japan Agency for Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG56-05] Electrical conductivity and spectral IP characteristics in the rock samples obtained in seafloor hydrothermal area and interpretation of them

*Yusuke Ohta[1], Tada-nori Goto[1], Katsuaki Koike[1], Weiren Lin[1], Koki Kashiwaya[1], Tadai Osamu[3], Takafumi Kasaya[2], Toshiya Kanamatsu[2], Hidenori Kumagai[2], Hideaki Machiyama[2] (1.Kyoto University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Marine Works Japan)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG56-06] Geological structure north offshore Ishigaki-Jima estimated from seismic reflection survey

*Ayanori Misawa[1], Seishiro Furuyama[2,1], Masahiko Sato[3,1], Jih-Shin Chang[1], Takahiko Inoue[1], Kohsaku Arai[1] (1.Geological Survey of Japan, AIST, 2.Tokyo University of Marine Science and Technology, 3.The University of Tokyo)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Keishiro Azami, Erika Tanaka

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG56-07] The first report of the evidence for hydrothermal activity in old oceanic plate

*Keishiro Azami[1], Shiki Machida[2], Naoto Hirano[3], Tetsu Kogiso[4], Yasuhiro Kato[1,2] (1.Department of System Innovation, School of Engineering, The University of Tokyo, 2.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 3.Center for Northeast Asian Studies, Tohoku University, 4.Graduate School of Human and Environmental Studies, Kyoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG56-08] X-ray computed tomography characterization of the distribution of biogenic apatite and sedimentary structures in pelagic clay around Minamitorishima Island, western North Pacific

*Yoichi Usui[1], Koichi Iijima[1], Hideaki Machiyama[1], Yuji Ichiyama[2,1], Erika Tanaka[3], Koichiro Fujinaga[4,3], Kazutaka Yasukawa[3,4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Chiba University, 3.The University of Tokyo, 4.Chiba Institute of Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG56-09] Geochemistry and distribution of REY-rich mud in the eastern off the Takuyo-Daigo Seamount within the Minamitorishima EEZ

*Koichiro Fujinaga[1,2], Kazutaka Yasukawa[3,1], Tatsuo Nozaki[4,2,1,5], Shiki Machida[1,2], Yutaro Takaya[6,2,1], Junichiro Ohta[1,2], Moei Yano[3], Ryo Shimomura[3], Erika Tanaka[3], Kazuhide Mimura[3], Koichi Horinouchi[3], Kenji Matsumoto[3], Yoichi Usui[4], Hirofumi Yamamoto[4], Kentaro Nakamura[3], Yasuhiro Kato[2,3,1], KM17-14C cruise members (1.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 2.Frontier Research Centerfor Energy and Resources, School of Engineering, The University of Tokyo, 3.Department of Systems Innovation, School of Engineering, The University of Tokyo, 4.Japan Agencyfor Marine-Earth Science and Technology, 5.Department of Planetology, Graduate Schoolof Science, Kobe University, 6.Department of Resources and Environmental Engineering School of Creative Science and Engineering, Waseda University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG56-10] Extended lateral correlation of deep-sea sediments around the Minamitorishima EEZ based on downhole variation of bulk chemical composition

*Erika Tanaka[1], Kentaro Nakamura[1], Kazutaka Yasukawa[1,2], Koichiro Fujinaga[2], Koichi Iijima[3], Shiki Machida[2], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.ORCeNG, Chiba Institute of Technology, 3.JAMSTEC)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG56-11] Tectonics of the abyssal basins surrounding the Ontong Java Plateau

*Masao Nakanishi[1], Shoka Shimizu[2], Daisuke Suetsugu[3], Takashi Sano[4] (1.Department of Earth Sciences, Graduate School of Science, Chiba University, 2.Department of Earth Sciences, Graduate School of Science and Technology, Chiba University, 3. Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology, 4.Department of Geology and Paleontology, National Museum of Nature and Science)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG56-12] **The Cretaceous Normal Superchron: records from the Pacific, Indian and Atlantic oceanic crust**

*Nobukazu Seama[1,2], Jerome Dyment[3], Taichi Sato[4,5], Yves Gallet[6], Kyoko Okino[7], Roi Granot[8], Yoshifumi Nogi[9], Nobutatsu Mochizuki[10], Toshitsugu Yamazaki[7] (1.Department of Planetology, Kobe University, 2.KOBEC (Kobe Ocean-Bottom Exploration Center), Kobe University, 3.Institut de Physique du Globe de Paris, 4.National Institute of Advanced Industrial Science and Technology, 5.The Institute for Geoscience Research (TIGeR), Curtin University , 6.French Centre National de la Recherche Scientifique, 7.Atmosphere and Ocean Research Institute, The University of Tokyo, 8.Department of Geological and Environmental Sciences, Ben-Gurion University, 9.National Institute of Polar Research, 10.Priority Organization for Innovation and Excellence, Kumamoto University)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Chie Honsho, Tadashi Ishikawa

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG56-13] Offshore Postseismic Deformation of the 2011 Tohoku Earthquake Revisited: Application of an Improved GPS-Acoustic Positioning Method Considering Sloping Sound Speed Structure

*Chie Honsho[1], Motoyuki Kido[2], Fumiaki Tomita[3], Naoki Uchida[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University, 3.Graduate School of Science, Hokkaido University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG56-14] Comprehensive analysis for the forearc structure and dynamics by using the S-net data

*Naoki Uchida[1], Ryosuke Azuma[1], Akira Ishigami[1], Tomomi Okada[1], Ryota Takagi[1], Genti Toyokuni[1], Norihito Umino[1], Yusaku Ohta[1], Makiko Sato[1], Syuichi Suzuki[1], Hidenobu Takahashi[1], Kazuya Tateiwa[1], Dapeng Zhao[1], Takashi NAKAYAMA[1], Akira Hasegawa[1], Ryota Hino[1], Satoshi Hirahara[1], Toru Matsuzawa[1], Keisuke Yoshida[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG56-15] Shallow slow slip event inferred from GNSS-A seafloor geodesy

*Tadashi Ishikawa[1], Yusuke Yokota[2] (1.Hydrographic and Oceanographic Department, Japan Coast Guard, 2.Institute of Industrial Science, the University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG56-16] Assessing strike-slip motion at the Shionomisaki Canyon along the Nankai oblique subduction zone using acoustic ranging system

*Motoyuki Kido[1], Eiichiro Araki[2], Takeshi Tsuji[3], Ryusuke Yamamoto[4], Yoshifumi Kawada[1] (1.International Research Institute for Disaster Science, Tohoku University, 2.JAMSTEC, 3.Dept. Earth Resources Engineering, Kyushu University, 4.School of Science, Tohoku University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG56-17] Development of seafloor realtime observation network for crustal deformation in the Nankai Trough: tiltmeter installation

*Eiichiro Araki[1], Takashi Yokobiki[1], Toshinori Kimura[1], Shuhei Nishida[1], Yuya Machida[1], Shuichi Kodaira[1] (1.Japan Agency for Marine-Earth Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG56-18] Calibration of the DONET pressure sensor network in the Nankai trough seismogenic zone using a mobile pressure gauge

*Yuya Machida[1], Shuhei Nishida[1], Toshinori Kimura[1], Eiichiro Araki[1] (1.Japan Agency for Marine-Earth Science and Technology)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Misae Imano, Tetsuo No

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SCG56-19] Analysis of GNSS/Acoustic geodetic data including the period of the transponder replacement

*Ikuta Ryoya[1], Koto Mizuno[1], Horng-Yue Chen[3], Masataka Ando[2], Takeru Komi[1] (1.Faculty of Science, Shizuoka University, 2.Center for Integrated Research and Education of Natural Hazards, Shizuoka University, 3.Institute of Earth Science, Academia Sinica)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SCG56-20] IPR (Indirect Path Ranging): a new approach for long-distance acoustic ranging with a moored relay node

*Ryusuke Yamamoto[1], Ryota Hino[1], Motoyuki Kido[2] (1.Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG56-21] Development of a kinematic GNSS-A positioning method using the extended Kalman-filter to detect precise vertical displacement

*Fumiaki Tomita[1], Motoyuki Kido[2], Chie Honsho[3], Ryo Matsui[3] (1.Graduate School of Science, Hokkaido University, 2.International Research Institute of Disaster Science, Tohoku University, 3.Graduate School of Science, Tohoku University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG56-22] DOP-based accuracy evaluation of GNSS-A positioning on a drifting moored buoy quantified using sea trial observation data

*Misae Imano[1], Motoyuki Kido[2,3], Chie Honsho[3], Yusaku Ohta[3], Ryota Hino[3] (1.Graduate School of Science, Tohoku University, 2.nternational Research Institute for Disaster Science, Tohoku University, 3.Reserch Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG56-23] Analysis for GNSS/acoustic ocean bottom crustal deformation considering the heterogeneity of sound speed structure in ocean

*Natsuki Kinugasa[1], Keiichi Tadokoro[1], Yukihiro Terada[2], Teruyuki Kato[3] (1.Graduate School of Environmental Studies, Nagoya University, 2.National Institute of Technology, Kochi College, 3.Hot Springs Research Institute of Kanagawa Prefectural Government)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG56-24] Seismic imaging using ocean bottom nodes in the Ishikari Basin, Japan Sea

*Tetsuo No[1], Takeshi Sato[1], Shuichi Kodaira[1], Satoshi Shimizu[2], Tetsuya Yokota[2], Karl Hosgood[3], Masako Robb[3], Tetsuro Tsuru[4] (1.JAMSTEC, 2.Nippon Marine Enterprises, 3.Emerson E&P Software, 4.Tokyo University of Marine Science and Technology)

[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 304 3F

[S-CG62] Potentiality of Machine Learning in Solid Earth Sciences

convener:Takahiko Uchide(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Chairperson:Takahiko Uchide(Geological Survey of Japan, AIST), Hirokuni Oda

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[SCG62-01] The Promise of Machine Learning in Solid Earth Geoscience: Examples from Seismology

★Invited Papers

*Gregory C Beroza[1], Mostafa Mousavi[1], Weiqiang Zhu[1], Karianne J Bergen[2], Paul A Johnson[3], Maarten V De Hoop[4] (1.Stanford University, 2.Harvard University, 3.Los Alamos National Laboratory, 4.Rice University)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[SCG62-02] **Automatic Approach to Low-Frequency Earthquakes Detection in Southwest Japan Based on Deep Learning Technique**

*Yu Junyu[1], Yuji Yagi[1], Takanori Matsuzawa[2], Ryo Okuwaki[1] (1.Graduate School of Life and Environmental Sciences,University of Tsukuba, Tsukuba, 2.National Research Institute for Earth Science and Disaster Resilience)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[SCG62-03] Broadband ground motion waveform synthesis utilizing AI-based upsampling technique (2)

*Takahiro Maeda[1], Asako Iwaki[1], Hiroyuki Fujiwara[1], Kazutoshi Matsuzaki[2], Hiromitsu Tomozawa[2], Yuji Mori[2], Misato Tsuchiya[2], Naofumi Miyata[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Mizuho Information & Research Institute, Inc.)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[SCG62-04] Forecast trial of postseismic deformetion after the 2011 Tohoku-Oki earthquake by recurrent neural network

*Norifumi Yamaga[1], Yuta Mitsui[2] (1.Graduate School of Science and Technology, Shizuoka University, 2.Shizuoka University)

10:05 AM - 10:25 AM JST | 1:05 AM - 1:25 AM UTC

[SCG62-05] Deep Learning Approaches for Eruption Prediction of Sakurajima

★Invited Papers

*Tsuyoshi Murata[1] (1.Tokyo Institute of Technology)

[J] Poster | S (Solid Earth Sciences)：S-CG Complex & General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_21

[S-CG62] Potentiality of Machine Learning in Solid Earth Sciences

convener:Takahiko Uchide(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST)

[SCG62-P01] Earthquake Magnitude Prediction with Seismic Nucleation Phase based on Machine Learning

*Kangming Wu[1], Hiroe Miyake[2] (1.GSII, The University of Tokyo, 2.III, The University of Tokyo)

[SCG62-P02] Automatic signal classification for continuous seismic waveform records based on an unsupervised learning algorithm: Application to artificial noises and low-frequency tremors

*Yuki Kodera[1], Shin'ichi Sakai[2], Takahito Nishimiya[1] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.Earthquake Research Institute, the University of Tokyo)

[SCG62-P03] Detection of Gas Bubble signals recorded at the OBS Stations by Machine-Learning

*emmy TY CHANG[1] (1.Institute of Oceanography, National Taiwan University)

[SCG62-P04] Automatic Phase Picking of Seismograms by Deep Neural Network

*Takahiko Uchide[1] (1.Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST))

[SCG62-P05] **Seismic event detection in time-frequency domain with CNN and phase picking with HED**

*Liping Fan[1] (1.Institute of Geophysics, China Earthquake Administration)

[SCG62-P06] Broadband ground-motion synthesis using embeddig machine learning

*Tomohisa Okazaki[1], Hirotaka Hachiya[1], Naonori Ueda[1], Asako Iwaki[2], Takahiro Maeda[2], Hiroyuki Fujiwara[2] (1.Center for Advanced Intelligence Project, RIKEN, 2.National Research Institute for Earth Science and Disaster Resilience)

[SCG62-P07] LSTM and CNN Applications to Forecast Earthquake Magnitude Probability Distribution

*Qi Liu[1], Hiroe Miyake[2], Hiroshi Tsuruoka[3] (1.GSII, The University of Tokyo, 2.III, The University of Tokyo, 3.ERI, The University of Tokyo)

[SCG62-P08] *FORCsensei*: A machine learning framework to estimate optimized first-order reversal curve distributions

David Heslop[1,2], Andrew Roberts[1,2], *Hirokuni Oda[2], Xiang Zhao[1,2], Richard Harrison[3], Adrian Muxworthy[4], Pengxiang Hu[1,2], Tetsuro Sato[2] (1.Australian National University, 2.Institute of Geology and Geoinformation, Geological Survey of Japan, AIST, 3.University of Cambridge, 4.Imperial College London)

[J] Poster | S (Solid Earth Sciences)：S-CG Complex & General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_35

[S-CG62] Potentiality of Machine Learning in Solid Earth Sciences

convener:Takahiko Uchide(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST)

[SCG62-P01] Earthquake Magnitude Prediction with Seismic Nucleation Phase based on Machine Learning

*Kangming Wu[1], Hiroe Miyake[2] (1.GSII, The University of Tokyo, 2.III, The University of Tokyo)

[SCG62-P02] Automatic signal classification for continuous seismic waveform records based on an unsupervised learning algorithm: Application to artificial noises and low-frequency tremors

*Yuki Kodera[1], Shin'ichi Sakai[2], Takahito Nishimiya[1] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.Earthquake Research Institute, the University of Tokyo)

[SCG62-P03] Detection of Gas Bubble signals recorded at the OBS Stations by Machine-Learning

*emmy TY CHANG[1] (1.Institute of Oceanography, National Taiwan University)

[SCG62-P04] Automatic Phase Picking of Seismograms by Deep Neural Network

*Takahiko Uchide[1] (1.Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST))

[SCG62-P05] **Seismic event detection in time-frequency domain with CNN and phase picking with HED**

*Liping Fan[1] (1.Institute of Geophysics, China Earthquake Administration)

[SCG62-P06] Broadband ground-motion synthesis using embeddig machine learning

*Tomohisa Okazaki[1], Hirotaka Hachiya[1], Naonori Ueda[1], Asako Iwaki[2], Takahiro Maeda[2], Hiroyuki Fujiwara[2] (1.Center for Advanced Intelligence Project, RIKEN, 2.National Research Institute for Earth Science and Disaster Resilience)

[SCG62-P07] LSTM and CNN Applications to Forecast Earthquake Magnitude Probability Distribution

*Qi Liu[1], Hiroe Miyake[2], Hiroshi Tsuruoka[3] (1.GSII, The University of Tokyo, 2.III, The University of Tokyo, 3.ERI, The University of Tokyo)

[SCG62-P08] *FORCsensei*: A machine learning framework to estimate optimized first-order reversal curve distributions

David Heslop[1,2], Andrew Roberts[1,2], *Hirokuni Oda[2], Xiang Zhao[1,2], Richard Harrison[3], Adrian Muxworthy[4], Pengxiang Hu[1,2], Tetsuro Sato[2] (1.Australian National University, 2.Institute of Geology and Geoinformation, Geological Survey of Japan, AIST, 3.University of Cambridge, 4.Imperial College London)

[E] Oral | B (Biogeosciences) : B-PT Paleontology

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 201A 2F

[B-PT04] Biomineralization and the Geochemistry of Proxies

convener:Takashi Toyofuku(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Hiroshi Kitazato(Tokyo University of Marine Science and Technology (TUMSAT)), Jelle Bijma(Alfred-Wegener-Institut Helmholtz-Zentrum f?r Polar- und Meeresforschung), Kotaro Hirose(Faculty of Science & Engineering, Waseda University), Chairperson:Kotaro Hirose(Waseda University School of Creative Science and Engineering), Takashi Toyofuku

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[BPT04-01] Long term size changes of the Middle Miocene planktonic foraminifera in the eastern equatorial Pacific

★Invited Papers

*Takuma Suzuki[1], Hiroki Hayashi[1] (1.Shimane University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[BPT04-02] Mathematical models for the geochemical composition of foraminiferal calcium carbonate

*Jelle Bijma[1], Dieter Wolf-Gladrow[1] (1.Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[BPT04-03] Response of structurally substituted sulfur in foraminifera shells to glacial-interglacial changes: a 1.0-million-year record from the Ontong-Java Plateau

*Toshihiro Yoshimura[1], Yusuke Tamenori[2], Junichiro Kuroda[3], Azumi Kuroyanagi[4], Naohiko Ohkouchi[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Synchrotron Radiation Research Institute, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Tohoku University Museum, Tohoku University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[BPT04-04] Transcript assembly and quantification identify candidate genes for foraminiferal calcification

*Yurika Ujiie[1], Yoshiyuki Ishitani[2], Shun'ichi Ishii[3], Yukiko Nagai[3], Yoshihiro Takaki[3], Tetsuro Ikuta[3], Takashi Toyofuku[3] (1.Center for Advanced Marine Core Research, Kochi University, 2.Center for Computational Sciences, University of Tsukuba, 3.Japan Agency for Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[BPT04-05] Characterization of cogwheel structures in foraminifera

★Invited Papers

*Inge van Dijk[1], Markus Raitzsch[2], Gernot Nehrke[1], Jelle Bijma[1] (1.Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Am Handelshafen 12, Bremerhaven 27570, Germany, 2.MARUM - Zentrum für Marine Umweltwissenschaften, Universität Bremen, Leobener Str., 28359 Bremen, Germany)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[BPT04-06] Benthic foraminiferal characterizations from the seascape point of view

*Hiroshi Kitazato[1] (1.Tokyo University of Marine Science and Technology (TUMSAT))

[E] Oral | B (Biogeosciences)：B-PT Paleontology

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 201A 2F

[B-PT04] Biomineralization and the Geochemistry of Proxies

convener:Takashi Toyofuku(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Hiroshi Kitazato(Tokyo University of Marine Science and Technology (TUMSAT)), Jelle Bijma(Alfred-Wegener-Institut Helmholtz-Zentrum f?r Polar- und Meeresforschung), Kotaro Hirose(Faculty of Science & Engineering, Waseda University), Chairperson:Jelle Bijma(AWI), 北里 洋

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[BPT04-07] Skeleton microstructures of aposymbiotic scleractinian coral cultured in seawater with various Mg/Ca ratios

*Satoko Motai[1], Naotaka Tomioka[1], Jun Kawano[2], Saki Harii[3], Takaya Nagai[2], Tsuyoshi Watanabe[2], Yu Kodama[4], Motoo Ito[1] (1.Japan Agency for Marine-Earth and Technology, 2.Hokkaido University, 3.University of the Ryukyus, 4.Marine Works Japan)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[BPT04-08] Skeletal formation of scleractinian corals in response to Mg/Ca fluctuation

*Tomihiko Higuchi[1], Ikuko Yuyama[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.University of Tsukuba)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[BPT04-09] **Inter-specific variations in trace element concentrations of modern brachiopod shells collected from Otsuchi Bay, Japan**

*Takuya Nishio[1], Hideko Takayanagi[1], Ryuji Asami[1], Ryuichi Shinjo[2], Koshi Yamamoto[3], Yasufumi Iryu[1] (1.Institute of Geology and Paleontology, Graduate School of Science, Tohoku University, 2.Graduate School of Engineering and Science, University of the Ryukyus, 3.Graduate School of Environmental Studies, Nagoya University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[BPT04-10] Trace element concentrations of sub-tropical modern brachiopod *Basiliola lucida* collected off Okinawa-jima, Japan

*Hideko Takayanagi[1], Tomoko Tochigi[1], Ryuji Asami[1], Ryuichi Shinjo[2], Takuya Itaki[3], Yasufumi Iryu[1] (1.Tohoku University, 2.University of the Ryukyus, 3.Advanced Industrial Science and Technology (AIST))

11:45 AM - 12:05 PM JST | 2:45 AM - 3:05 AM UTC

[BPT04-11] Structural difference between phaeodarians and radiolarians (unicellular zooplankton)

★Invited Papers

*Yasuhide Nakamura[1], Rie Hori, S.[2], Akihiro Tuji[1], Hiroaki Ohfuji[2], Noritoshi Suzuki[3], Katsunori Kimoto[4] (1.National Museum of Nature and Science, 2.Ehime University, 3.Tohoku University, 4.JAMSTEC)

[E] Poster | B (Biogeosciences)：B-PT Paleontology

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_22

[B-PT04] Biomineralization and the Geochemistry of Proxies

convener:Takashi Toyofuku(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Hiroshi Kitazato(Tokyo University of Marine Science and Technology (TUMSAT)), Jelle Bijma(Alfred-Wegener-Institut Helmholtz-Zentrum f?r Polar- und Meeresforschung), Kotaro Hirose(Faculty of Science & Engineering, Waseda University)

[BPT04-P01] Living (stained) benthic foraminifera in the West-Gironde mud patch (Bay of Biscay, France): An ongoing survey for the European Community.

*Christophe Fontanier[1,2], Bruno Deflandre[1], Sylvain Rigaud[3], Sabine Schmidt[1], Bastien Lamarque[1], Pascal Lebleu[1], Dominique Poirier[1], Antoine Grémare[1] (1. Bordeaux University, EPOC Laboratory, UMR CNRS 5805 OASU, F-33615 Pessac, FRANCE, 2.FORAM Research Group, F-49140 Villevêque, FRANCE, 3.Nîmes University, GIS Laboratory, EA 7352 CHROME, F-30035 Nïmes, FRANCE)

[BPT04-P02] Biomonitoring in the Cassidaigne Canyon (NW Mediterranean): the resilience and recovery of deep-sea benthic foraminifera at a bauxite industrial waste site

*Pauline Duros[1], Christophe Fontanier[1,2,3], Briony Mamo[4,5], Deborah Mille[6], Olivier Herlory[6] (1.FORAM Research Group, F-49140 Villevêque, FRANCE, 2.Bordeaux University, EPOC Laboratory, UMR CNRS 5805 OASU, F-33615 Pessac, FRANCE, 3.Angers University, 4 boulevard Lavoisier, F-49000 Angers, FRANCE., 4.School of Biological Sciences, University of Hong Kong, Pokfulam Road Sai Wan, Hong Kong SAR, CHINA. , 5.Department of Biology, Macquarie University, North Ryde, NSW, 2109, AUSTRALIA., 6.CREOCEAN, Agence PACA Corse, 230 Avenue de Rome, Valparc-Bât B, F-83500 La Seyne sur Mer, FRANCE.)

[BPT04-P03] Comparison between assemblages of diatom fossil and biomarkers in surface sediments from Seto Inland Sea

*Kotaro Hirose[1], Hideto Nakamura[2], Takuto Ando[4], Satoshi Asaoka[3], Ken Sawada[5] (1.Faculty of Science & Engineering, Waseda University, 2.Faculty of Science, Osaka City University, 3.Research Center for Inland Seas & Department of Planetology, Kobe University, 4.Arctic Research Center, Hokkaido University, 5.Department of Earth & Planetary Science, Faculty of Science, Hokkaido University)

[BPT04-P04] Combined impacts of ocean acidification and desalination: culture experiments on the coastal species *Ammonia* sp. and *Elphidium crispum*

*Laurie Marie Charrieau[1], Helena L. Filipsson[2], Yukiko Nagai[1], Sachiko Kawada[1], Karl Ljung[2], Emma Kritzberg[3], Takashi Toyofuku[1,4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Department of Geology, Lund University, Sweden, 3.Department of Biology, Lund University, Sweden, 4.Tokyo University of Marine Science and Technology (TUMSAT), Japan)

[BPT04-P05] Effects on larger benthic foraminiferal shell density under global warming

★Invited Papers

*Shunichi Kinoshita[1], Azumi Kuroyanagi[2], Hiroshi Nishi[2], Osamu Sasaki[2], Kazuhiko Fujita[3], Atsushi Suzuki[4], Hodaka Kawahata[5] (1.Graduate School of Science, Tohoku University, 2.The Tohoku University Museum, The Center for Academic Resources and Archives, Tohoku Univerity, 3.Department of Physics and Earth Sciences, Faculty of Science and Tropical Biosphere Research Center, University of the Ryukyus, 4.Geological Survey of Japan National Institute of Advanced Industrial Science and Technology, 5.Atmosphere and Ocean Research Institute, the University of Tokyo)

[BPT04-P06] Estimation of the calcification rate of foraminifera -exceptionally fast extending of the shell-

*Yukiko Nagai[1,2], Katsuyuki Uematsu[3], Takashi Toyofuku[2,4] (1.National Museum of Nature and Science of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Marine Works Japan Enterprise, 4.Tokyo university of Marine Science and Technology)

[BPT04-P07] Estimation of foraminiferal calcification process from live imaging and FIB-SEM approach

*Takashi Toyofuku[1,2], Yukiko Nagai[1,3] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.Tokyo University of Marine Science and Technology, 3.National Museum of Nature and Science,Tokyo)

[BPT04-P08] Toward a better understanding of planktic foraminiferal proxies: Are they photosymbiotic or not?

*Haruka TAKAGI[1], Katsunori KIMOTO[2], Tetsuichi FUJIKI[2], Kazuyoshi MORIYA[3], Hiroaki SAITO[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology,

3.School of Education, Waseda University)

[BPT04-P09] Evaluation of geochemistry in hypercalcified demosponges as a paleoceanographic proxy

*Ryuji Asami[1], Tohru Naruse[2], Masaru Mizuyama[3], Ryu Uemura[3], Ryuichi Shinjo[3], Yuji Ise[4], Yoshihisa Fujita[5], Takashi Sakamaki[6] (1.Graduate School of Science, Tohoku University, 2.Tropical Biosphere Research Center, University of the Ryukyus, 3.Faculty of Science, University of the Ryukyus, 4.Centre for Marine and Coastal Studies, Universiti Sains Malaysis, 5.Okinawa Prefectural University of Arts, 6.Graduate School of Engineering, Tohoku University)

[E] Poster | B (Biogeosciences)：B-PT Paleontology

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_36

[B-PT04] Biomineralization and the Geochemistry of Proxies

convener:Takashi Toyofuku(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Hiroshi Kitazato(Tokyo University of Marine Science and Technology (TUMSAT)), Jelle Bijma(Alfred-Wegener-Institut Helmholtz-Zentrum f?r Polar- und Meeresforschung), Kotaro Hirose(Faculty of Science & Engineering, Waseda University)

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*Pauline Duros[1], Christophe Fontanier[1,2,3], Briony Mamo[4,5], Deborah Mille[6], Olivier Herlory[6] (1.FORAM Research Group, F-49140 Villevêque, FRANCE, 2.Bordeaux University, EPOC Laboratory, UMR CNRS 5805 OASU, F-33615 Pessac, FRANCE, 3.Angers University, 4 boulevard Lavoisier, F-49000 Angers, FRANCE., 4.School of Biological Sciences, University of Hong Kong, Pokfulam Road Sai Wan, Hong Kong SAR, CHINA. , 5.Department of Biology, Macquarie University, North Ryde, NSW, 2109, AUSTRALIA., 6.CREOCEAN, Agence PACA Corse, 230 Avenue de Rome, Valparc-Bât B, F-83500 La Seyne sur Mer, FRANCE.)

[BPT04-P03] Comparison between assemblages of diatom fossil and biomarkers in surface sediments from Seto Inland Sea

*Kotaro Hirose[1], Hideto Nakamura[2], Takuto Ando[4], Satoshi Asaoka[3], Ken Sawada[5] (1.Faculty of Science & Engineering, Waseda University, 2.Faculty of Science, Osaka City University, 3.Research Center for Inland Seas & Department of Planetology, Kobe University, 4.Arctic Research Center, Hokkaido University, 5.Department of Earth & Planetary Science, Faculty of Science, Hokkaido University)

[BPT04-P04] Combined impacts of ocean acidification and desalination: culture experiments on the coastal species *Ammonia* sp. and *Elphidium crispum*

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[BPT04-P05] Effects on larger benthic foraminiferal shell density under global warming

★Invited Papers

*Shunichi Kinoshita[1], Azumi Kuroyanagi[2], Hiroshi Nishi[2], Osamu Sasaki[2], Kazuhiko Fujita[3], Atsushi Suzuki[4], Hodaka Kawahata[5] (1.Graduate School of Science, Tohoku University, 2.The Tohoku University Museum, The Center for Academic Resources and Archives, Tohoku Univerity, 3.Department of Physics and Earth Sciences, Faculty of Science and Tropical Biosphere Research Center, University of the Ryukyus, 4.Geological Survey of Japan National Institute of Advanced Industrial Science and Technology, 5.Atmosphere and Ocean Research Institute, the University of Tokyo)

[BPT04-P06] Estimation of the calcification rate of foraminifera -exceptionally fast extending of the shell-

*Yukiko Nagai[1,2], Katsuyuki Uematsu[3], Takashi Toyofuku[2,4] (1.National Museum of Nature and Science of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Marine Works Japan Enterprise, 4.Tokyo university of Marine Science and Technology)

[BPT04-P07] Estimation of foraminiferal calcification process from live imaging and FIB-SEM approach

*Takashi Toyofuku[1,2], Yukiko Nagai[1,3] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC), 2.Tokyo University of Marine Science and Technology, 3.National Museum of Nature and Science,Tokyo)

[BPT04-P08] Toward a better understanding of planktic foraminiferal proxies: Are they photosymbiotic or not?

*Haruka TAKAGI[1], Katsunori KIMOTO[2], Tetsuichi FUJIKI[2], Kazuyoshi MORIYA[3], Hiroaki SAITO[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology,

3.School of Education, Waseda University)

[BPT04-P09] Evaluation of geochemistry in hypercalcified demosponges as a paleoceanographic proxy

*Ryuji Asami[1], Tohru Naruse[2], Masaru Mizuyama[3], Ryu Uemura[3], Ryuichi Shinjo[3], Yuji Ise[4], Yoshihisa Fujita[5], Takashi Sakamaki[6] (1.Graduate School of Science, Tohoku University, 2.Tropical Biosphere Research Center, University of the Ryukyus, 3.Faculty of Science, University of the Ryukyus, 4.Centre for Marine and Coastal Studies, Universiti Sains Malaysis, 5.Okinawa Prefectural University of Arts, 6.Graduate School of Engineering, Tohoku University)

[J] Oral | G (General) : General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 104 1F

[G-01] Disaster prevention education

convener:Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education), Jiro Komori(Teikyo Heisei University), Shintaro Hayashi(Akita University Graduate School of Education), Chairperson:Jiro Komori(Teikyo Heisei University)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[G01-01] New high school compulsory subjects"Chiri-sougou(Comprehensive geography)"! : Possibility to promote disaster education

*Shintaro Hayashi[1] (1.Akita University Graduate School of Education)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[G01-02] Kyushu University's multidisciplinary disaster prevention education for students near nuclear power plants after 2016 Kumamoto earthquake

*Megumi Sugimoto[1,2], Silvia Peppoloni[2] (1.Kyushu University, 2.International Association for Promoting Geoethics)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[G01-03] The cases of the limit of dam impoundment during floods and necessity of information sharing at local disaster prevention

*Jiro Komori[1], Yuuri Masuhara[1] (1.Teikyo Heisei University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[G01-04] Disaster Tradition and Disaster Education of 2008 Sichuan Earthquake

★Invited Papers

*FU SIQI[1], Shiroshita Hideyuki[1] (1.Kansai University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[G01-05] Preparedness for Nankai Trough Earthquake: Incorporating Understandings of Uncertainties in Disaster Prevention Education Schemes

*Manabu Hashimoto[1], Mika Shimizu[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Center for the Promotion of Interdisciplinary Education and Research, Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[G01-06] Importance of issuing evacuation for individual family

★Invited Papers

*Suzuki Shigeyuki[1] (1.Okayama University)

[J] Poster | G (General)：General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_23

[G-01] Disaster prevention education

convener:Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education), Jiro Komori(Teikyo Heisei University), Shintaro Hayashi(Akita University Graduate School of Education)

[G01-P01] Application of GSI's Products for Disaster Prevention Education

*Takaki Okatani[1] (1.Geospatial Information Authority of Japan, Ministry of Land, Infrastructure, Transport and Tourism)

[G01-P02] Reconstruction of the image of the debris flow of the1898 disaster at the southern foot of Yatsugatake and the possibility of raising awareness of the local residents

*Hitoshi Nakai[1] (1.Kobuchisawa Research Institute for Nature and Education)

[G01-P03] Provisional report of the questionnair survey results to junior high school students regarding to natural disaster

*Norihito Kawamura[1], Kyoichi Takahashi[1] (1.Faculty of Education and Human Studies, Akita University)

[G01-P04] Disaster prevention education on estimation of earthquake damage on the campus

*Takeshi Yamagata[1] (1.Department of Natural Sciences, Komazawa university)

[G01-P05] Report of disaster mitigation childcare in kindergarten

*Nobuyuki Yamada[1], Kaoru Choji[2] (1.Kochi University, 2.Wakayama University)

[G01-P06] Utilization of Digital Resources to Facilitate Disaster Prevention Comprehension

*Tadayoshi Kato[1] (1.Moegino JHS.)

[G01-P07] Disaster Triangle – A Conceptual Device for Implementing Comprehensive and Continuous Disaster Education into School Science –

*Yuko Nomura[1] (1.National Researcn Institute of Fire and Disaster)

[G01-P08] RECOMMENDATIONS FOR DISASTER EDUCATION FOCUSING ON GEOGRAPHICAL CHARACTERISTICS

*Kenta Kawakami[1], Nobuhisa Matsuta[1] (1.Okayama University Graduate School)

[J] Poster | G (General) : General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_37

[G-01] Disaster prevention education

convener:Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education), Jiro Komori(Teikyo Heisei University), Shintaro Hayashi(Akita University Graduate School of Education)

[G01-P01] Application of GSI's Products for Disaster Prevention Education

*Takaki Okatani[1] (1.Geospatial Information Authority of Japan, Ministry of Land, Infrastructure, Transport and Tourism)

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*Takeshi Yamagata[1] (1.Department of Natural Sciences, Komazawa university)

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*Kenta Kawakami[1], Nobuhisa Matsuta[1] (1.Okayama University Graduate School)

[J] Oral | G (General) : General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 103 1F

[G-02] Geoscinece Outreach

convener:Takeyuki Ueki(Faculty of Risk and Crisis Management, Chiba Institute of Science), Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Satoko Oki(Faculty of Environment and information Studies), Chairperson:Satoko Oki

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[G02-01] Outreach of geography on general books

*Naoko HASEGAWA[1], Yuuki NAKAGAWA[1] (1.Ochanomizu University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[G02-02] **Dissemination of geographical and archaeological thinking by museum exhibitions: Practical approaches using three-dimensional models**

*Yuichi S. Hayakawa[1,2], Sahoko Aki[2] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Center for Spatial Information Science, The University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[G02-03] Introduction of Guide Skill Up Course and Its Effect in the Izu Peninsula Geopark

*Tsuda Kazuhide[1], Hiroshi Ono[1], Hiroshi Yamazaki[1], Akifumi Matsuo[1], Hideki Ono[2] (1.NPO Whole Earth Institute, 2.Izu Peninsula Geopark Promotion Conucil Bureau)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[G02-04] Testcase of Science Cafe with Confrontation Axis Considerd to Complex of Earth and Space Science

*Harufumi Tamazawa[1,2], Yuko Ikkatai[3] (1. Disaster Prevention Research Institute, Kyoto University, 2.Faculty of Fine Arts, Kyoto City University of Arts, 3.kabli Institute for the Physics and Mathematics of the Universe, University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[G02-05] Literacy for Rumors of Earthquake Occurrence

*Yoshiaki Orihara[1], Masashi Kamogawa[2], Toshiyasu Nagao[1] (1.Institute of Oceanic Research and Development, Tokai University, 2.Department of Physics, Tokyo Gakugei University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[G02-06] **Regional crustal movements and gigantic tsunami traces recorded by ghost forests: Importance of outreach activities and education for disaster prevention**

★Invited Papers

*Kiyoyuki Shigeno[1], Futoshi Nanayama[2,6], Kazuaki Watanabe[2], Masayuki Ishii[3], Kazuhito Ishiwata[4], Shigeto Inokuma[5], Keita Fukatsu[7] (1.Meiji consultant co.,Ltd., 2.Geological Survey of Japan, AIST, 3.Ishii Professional Engineer Office, 4.Betsukai municipal museum, 5.Nemuro City museum history and nature, 6.CWMD, Kumamoto Univ., 7.Notsuke Peninsula Nature Center)

[J] Oral | G (General) : General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 103 1F

[G-02] Geoscinece Outreach

convener:Takeyuki Ueki(Faculty of Risk and Crisis Management, Chiba Institute of Science), Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Satoko Oki(Faculty of Environment and information Studies), Chairperson:Naoko HASEGAWA

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[G02-07] **Constructing quaking model in the geological club activity and discussion activities around crack investigation**

*Ryo S Nakamura[1] (1.Miyagi Rifu high school)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[G02-08] The Impact of Middle School Students' "BOSAI Narratives" on the Community of Tosashimizu City

*Risako Tokoro[1], Kei Usui[1], Ayana Kawasaki[2], Tosei Nagamatsu[3], Satoko Oki[2] (1.Keio University, Faculty of Policy Management, 2.Keio University, Faculty of Environment and Information Studies, 3.Keio Research Institute at SFC)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[G02-09] **Disaster Prevention Education Programs to Increase Risk Perception**

*Erina Hyuga[1], Hitomi Sasaki[1], Satoko Oki[1] (1.Keio University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[G02-10] Geoscience education for infants using geological specimen

*Naoki Morita[1,2], Mana Yasui[2,3], Hiroshi Hagiya[2,4] (1.Meisei University, 2.Non-Profit Organization Science and Art, 3.Waseda research institute for science and engineering, 4.Tokyo City University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[G02-11] Introducing Narrative Approach to Earthquake Disaster Prevention (BOSAI) Teacher Training: Practice in Saitama Prefecture

*Ami Pareek[1], Satoko Oki[1], Kohei Yamaguchi[1], Mirei Toba[1] (1.Keio University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[G02-12] Practice of Disaster Education in Mexico: "Cultural Tuning" Based on Comparative Study of Public Educational Curriculum Between Japan and Mexico

*Takuya Iwahori[1], Genta Nakano[1], Katsuya Yamori[1] (1.Disaster Prevention Research Insutitute, Kyoto University)

[J] Poster | G (General)：General

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_24

[G-02] Geoscinece Outreach

convener:Takeyuki Ueki(Faculty of Risk and Crisis Management, Chiba Institute of Science), Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Satoko Oki(Faculty of Environment and information Studies)

[G02-P01] Sand grain and the Earth - an educational attempt to show the crustal character by sand grain composition

*Hiroshi Hagiya[1] (1.Tokyo City University)

[G02-P02] Geology and geomorphology as seeds of lifelong learning

*Takeyuki Ueki[1] (1.Faculty of Risk and Crisis Management, Chiba Institute of Science)

[G02-P03] Educational effects in geoscience outreach through solid terrain models by desktop 3D printer

*Jiro Komori[1] (1.Teikyo Heisei University)

[G02-P04] Practice of environmental study utilizing local high-definition topographic data

*Takuro Ogura[1,2], Yuichi S. Hayakawa[3,4], Yasuhiko Tamura[4], Chiaki T. Oguchi[5], Masashi Morita[6], Kisara Shimizu[5], OGATA KEISUKE[7], Hiroyuki Yamauchi[4] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Graduate School of Environmental Sciences, Hokkaido University, 3.Faculty of Environmental Earth Science, Hokkaido University, 4.Center of Spatial Information Science, The University Of Tokyo , 5.Graduate School of Science and Engineering, Saitama University, 6.Faculty of Urban Innovation, Yokohama National University, 7.School of literature, Tsurumi University)

[G02-P05] Development of the hemispherical multi-touch panel for the rear-projection digital globe "Dagik Earth"

*Yukinobu Koyama[1], Naoki Hirota[1] (1.National Institute of Technology, Oita College)

[G02-P06] An interactive visualization system of earth observation satellite data using Dagik Earth and Joy-Con

*Ayane Kosugo[1], Hina Yamanuki[1], Zhiyan Liu[1], Kazuhito Ichii[1] (1.Center for Environmental Remote Sensing, Chiba University)

[G02-P07] The report of the International Earth Science Olympiad (IESO),2019

*Yutaka Takigami[1] (1.Kanto Gakuen University)

[G02-P08] 19th Children’s Summer School on Earthquake and Volcanoes in Izu-Oshima Geopark

*ai toma[1], tomoya hiiro[2], committee for children's Summer School on Earthquake and Volcanoes[3] (1.Keio University, 2.Graduate school of Shinshu University, 3.Seismological Society of japan・Volcanological Society of japan・Geological Society of japan)

[J] Poster | G (General) : General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_38

[G-02] Geoscinece Outreach

convener:Takeyuki Ueki(Faculty of Risk and Crisis Management, Chiba Institute of Science), Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Satoko Oki(Faculty of Environment and information Studies)

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*Hiroshi Hagiya[1] (1.Tokyo City University)

[G02-P02] Geology and geomorphology as seeds of lifelong learning

*Takeyuki Ueki[1] (1.Faculty of Risk and Crisis Management, Chiba Institute of Science)

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*Jiro Komori[1] (1.Teikyo Heisei University)

[G02-P04] Practice of environmental study utilizing local high-definition topographic data

*Takuro Ogura[1,2], Yuichi S. Hayakawa[3,4], Yasuhiko Tamura[4], Chiaki T. Oguchi[5], Masashi Morita[6], Kisara Shimizu[5], OGATA KEISUKE[7], Hiroyuki Yamauchi[4] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Graduate School of Environmental Sciences, Hokkaido University, 3.Faculty of Environmental Earth Science, Hokkaido University, 4.Center of Spatial Information Science, The University Of Tokyo , 5.Graduate School of Science and Engineering, Saitama University, 6.Faculty of Urban Innovation, Yokohama National University, 7.School of literature, Tsurumi University)

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[J] Oral | G (General) : General

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 104 1F

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School), Chairperson:Toshihiro Niwa

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[G03-01] "Science reading" in the Oki Island Library Let's science reading! The story of Light deliver "science reading and demonstration experiments in the Oki Island Library

*Kunihiro Abe[1] (1.Shimane Penunsula Shinjiko Narumi, Kuibiki Geopark Promotion Committee)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[G03-02] Difference in elementary students' understanding of a solar eclipse by using different ICT devices

*Koji Imai[1], Yasuhiro Murayama[1], Takahiro Yamanishi[2] (1.National Institute of Information and Communications Technology, 2.MITSUBISHI MINATOMIRAI INDUSTRIAL MUSEUM)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[G03-03] Let's learn landform and disaster risk

*Yuki Kurisu[1] (1.Geospatial Information Authority of Japan)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[G03-04] Demonstration of the serpentinite dehydration at a laboratory in school

*Soichi Omori[1], Yukinobu Katsumata[2] (1.The Faculty of Liberal Arts, The Open University of Japan, 2.Natural and Environmental Sciences Program, The Open University of Japan)

10:00 AM - 10:20 AM JST | 1:00 AM - 1:20 AM UTC

[G03-05] Educational activities of the Earth and planetary science in the collaboration of schools, science museums, and scientists using digital globe

*Akinori Saito[1], Takuya Tsugawa[2] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.National Institute of Information and Communications Technology)

[J] Poster | G (General) : General

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_8

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School)

[G03-P01] The ocean saline monitoring activities in the high school classes and science club activities as the ocean science education

*Ryo S Nakamura[1] (1.Miyagi Rifu high school)

[G03-P02] Collaboration between Visiting Lectures on Marine Science and Cubic Earth

*Yushi Morioka[1], Hiromichi Ueno[2], Naoki Fujii[3], Akihiro Senda[4], Tsuneo Ono[5], Sayaka Yasunaka[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Hokkaido University, 3.Saga University, 4.Japan Science Society, 5.Japan Fisheries Research and Education Agency)

[G03-P03] Understanding seismic waves propagating through the Earth's core graphically

*Mamoru Kato[1] (1.Graduate School of Human and Environmental Studies Kyoto University)

[G03-P04] Development of easy seismometer and fastest observations

*Shin'ichi Sakai[1], Satoshi Matsumoto[2], Yoshihisa Iio[3], Aitaro Kato[1] (1.Earthquake Research Institute, University of Tokyo, 2.Institute of Seismology and Volcanology, Faculty of Seiences, Kyushu University, 3.Disaster Prevention Research Institute, Kyoto University)

[G03-P05] Proposing an educationally supporting system, “rent a core” and “extract a core” service

*Takeyuki Ueki[1] (1.Faculty of Risk and Crisis Management, Chiba Institute of Science)

[G03-P06] Application of research data to junior high school, high school and university educations

*Norio Umemura[1], Yoshimasa Tanaka[2,3], Shuji Abe[4], Yasuo Saito[3], Shin ya Nakano[5], Atsuki Shinbori[1], Yasuyuki Minamiyama[3] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Polar Environment Data Science Center, Research Organization of Information and Systems, 3.National Institute of Polar Research, 4.International Center for Space Weather Science and Education, Kyushu University, 5.The Institute of Statistical Mathematics)

[G03-P07] The Education of Scientific Ethics of Science Research in Senior High School, a Pioneer in Japan

*Kazuya Kawakatsu[1] (1.Hyogo Prefectural Nishiwaki senior high school)

[J] Poster | G (General) : General

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_39

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School)

[G03-P01] The ocean saline monitoring activities in the high school classes and science club activities as the ocean science education

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[G03-P06] Application of research data to junior high school, high school and university educations

*Norio Umemura[1], Yoshimasa Tanaka[2,3], Shuji Abe[4], Yasuo Saito[3], Shin ya Nakano[5], Atsuki Shinbori[1], Yasuyuki Minamiyama[3] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Polar Environment Data Science Center, Research Organization of Information and Systems, 3.National Institute of Polar Research, 4.International Center for Space Weather Science and Education, Kyushu University, 5.The Institute of Statistical Mathematics)

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*Kazuya Kawakatsu[1] (1.Hyogo Prefectural Nishiwaki senior high school)

[J] Oral | G (General) : General

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 104 1F

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School), Chairperson:Masatsune Hatakeyama(Seikogakuin High school)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[G03-06] **Improving Awareness of Marine Conservation and Sustainability among Taiwanese Middle School Students by Teaching Slow Fish Movement**

*Ya-Yin Liao[1], Liang-Ting Tsai[2], Ting-Kuang Yeh[3], Cheng-Chieh Chang[1] (1.National Taiwan Ocean University Institute of Education , 2.Taiwan Marine Education Center, 3.National Taiwan Normal University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[G03-07] Prototyping of the teachable moment presetation for recent earthquakes in Japan (2) - - -The case of the 3 January 2019 Kumamoto earthquake (M5.1) on and improvement from the previous prototype- - -

*Reiji Kobayashi[1] (1.Graduate School of Science and Engineering, Kagoshima University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[G03-08] Development of web application for polarizing microscope observation

*Fumitoshi Morisato[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[G03-09] Usage and Utilization of 3D display function on GSI Maps

*Ryoichi Kojiroi[1] (1.Geospatial Information Authority of Japan)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[G03-10] Bringing field- and laboratory work into the classroom by using online modules in the edX platform

*Alejandra Quintanilla-Terminel[1], Matej Pec[1], Oliver Jagoutz[1] (1.Massachusetts Institute of Technology)

[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_9

[M-IS01] Environmental, socio-economic and climatic changes in Northern Eurasia

convener:Pavel Groisman(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA), Shamil Maksyutov(National Institute for Environmental Studies), Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS), Dmitry A Streletskiy(George Washington University)

[MIS01-P01] Effects of clear-cutting on carbon dioxide fluxes in a boreal forest ecosystem - results of numerical experiments with a three-dimensional turbulent exchange model

Yulia Mukhartova[3], Maria Dyachenko[3], Polina Mangura[3], Alexander Krupenko[3], *Alexander Olchev[1,2] (1.Faculty of Geography, Lomonosov Moscow State University, 2.A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, 3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P02] Retrieving the forest species composition from remote sensing data using a three-dimensional radiative transfer model

*Alexander Olchev[1,2], Natalia Levashova[3], Dmitry Lukyanenko[3] (1.Faculty of Geography, Lomonosov Moscow State University , 2.Severtsov Institute of Ecology and Evolution, Russian Academy of Science, 3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P03] Satellite-derived Burned Area for Siberia (1979 – 2000)

*Amber Jeanine Soja[1], Brian J. Stocks[2], Stefano Potter[3], Brendan Rogers[3], Donald R. Cahoon[4], Natasha Jurko[5], Susan G. Conard[6], William 'Bill' deGroot[5], Nadezhda Tchebakova[7] (1.National Iinstitute of Aerospace / NASA Langley Research Center, 2.B.J. Stocks Wildfire Investigations Ltd., 3.Woods Hole Research Center , 4.Terra Systems Research, 5.Canadian Forest Service/Service canadien des forêts, 6.George Mason University,Fairfax, VA, 7.Sukachev Institute of Forestry, Siberian Branch of the Russian Academy of Sciences)

[MIS01-P04] Analysis and prediction of hazardous hydrometeorological phenomena in the coastal areas of the Arctic

*Irina Repina[1,2] (1.A.M.Obukhov Institute of Atmospheric Physics RAS, 2.Lomonosov Moscow State University)

[MIS01-P05] Recent baric and climatic conditions over East Europe with a focus on Belarus

*Irina Danilovich[1], Vladimir Loginov[1], Pavel Groisman[2] (1. Institute for Nature Management National Academy of Science, Minsk, Belarus, 2. NC State University at NOAA National Centers for Environmental Information, Asheville, USA)

[MIS01-P06] Assessment of climatic and environmental conditions along the track of projected Kyzyl-Kuragino railway line (the Western Sayan Mountains)

★Invited Papers

*Aleksandra Alekseevna Mikheeva[1], Margarita Syromyatina[1], Yurii Kurochkin[1] (1.Institute of Earth Sciences, Saint Petersburg State University, Russia)

[MIS01-P07] Assessment of interlinkages among industrialization, climate change, and forest fire activity: Thematic study of the Republic of Sakha (Yakutia), Russia

*Kiunnei Kirillina[1], Wanglin Yan[1] (1.Graduate School of Media and Governance, Keio University SFC)

[MIS01-P08] Quantitative Evaluation of Winter Daily Precipitation over Northern Japan

*Minami Masuda[1], Akiyo Yatagai[1], Toshiyuki Nakaegawa[2], Kenji Kamiguchi[3] (1.Graduate School of Science and Technology, Hirosaki University, 2.Meteorological Research Institute/Japan Meteorological Agency, 3.Japan Meteorological Agency)

[MIS01-P09] Seasonal variation of wetland carbon dioxide and methane fluxes measured by automatic chambers at the Bakchar bog, West Siberia

*Shamil Maksyutov[1], Alexandre Fofonov[2], Denis Davydov[2], Oleg Krasnov[2], Tadanobu Nakayama[1], Mikhail Glagolev[3] (1.National Institute for Environmental Studies, 2.V.E. Zuev Institute of Atmospheric Optics, 3.M.V. Lomonosov Moscow State University)

[MIS01-P10] Climatic distances between origin and labor locations for migrants in a changing climate in Siberia by the end of the 21st century

*Elena I. Parfenova[1], Nadezhda M. Tchebakova[1] (1.V.N.Sukachev Institute of Forest SB RAS, FRC SB RAS)

[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_40

[M-IS01] Environmental, socio-economic and climatic changes in Northern Eurasia

convener:Pavel Groisman(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA), Shamil Maksyutov(National Institute for Environmental Studies), Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS), Dmitry A Streletskiy(George Washington University)

[MIS01-P01] Effects of clear-cutting on carbon dioxide fluxes in a boreal forest ecosystem - results of numerical experiments with a three-dimensional turbulent exchange model

Yulia Mukhartova[3], Maria Dyachenko[3], Polina Mangura[3], Alexander Krupenko[3], *Alexander Olchev[1,2] (1.Faculty of Geography, Lomonosov Moscow State University, 2.A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, 3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P02] Retrieving the forest species composition from remote sensing data using a three-dimensional radiative transfer model

*Alexander Olchev[1,2], Natalia Levashova[3], Dmitry Lukyanenko[3] (1.Faculty of Geography, Lomonosov Moscow State University , 2.Severtsov Institute of Ecology and Evolution, Russian Academy of Science, 3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P03] Satellite-derived Burned Area for Siberia (1979 – 2000)

*Amber Jeanine Soja[1], Brian J. Stocks[2], Stefano Potter[3], Brendan Rogers[3], Donald R. Cahoon[4], Natasha Jurko[5], Susan G. Conard[6], William 'Bill' deGroot[5], Nadezhda Tchebakova[7] (1.National Iinstitute of Aerospace / NASA Langley Research Center, 2.B.J. Stocks Wildfire Investigations Ltd., 3.Woods Hole Research Center , 4.Terra Systems Research, 5.Canadian Forest Service/Service canadien des forêts, 6.George Mason University,Fairfax, VA, 7.Sukachev Institute of Forestry, Siberian Branch of the Russian Academy of Sciences)

[MIS01-P04] Analysis and prediction of hazardous hydrometeorological phenomena in the coastal areas of the Arctic

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[MIS01-P05] Recent baric and climatic conditions over East Europe with a focus on Belarus

*Irina Danilovich[1], Vladimir Loginov[1], Pavel Groisman[2] (1. Institute for Nature Management National Academy of Science, Minsk, Belarus, 2. NC State University at NOAA National Centers for Environmental Information, Asheville, USA)

[MIS01-P06] Assessment of climatic and environmental conditions along the track of projected Kyzyl-Kuragino railway line (the Western Sayan Mountains)

★Invited Papers

*Aleksandra Alekseevna Mikheeva[1], Margarita Syromyatina[1], Yurii Kurochkin[1] (1.Institute of Earth Sciences, Saint Petersburg State University, Russia)

[MIS01-P07] Assessment of interlinkages among industrialization, climate change, and forest fire activity: Thematic study of the Republic of Sakha (Yakutia), Russia

*Kiunnei Kirillina[1], Wanglin Yan[1] (1.Graduate School of Media and Governance, Keio University SFC)

[MIS01-P08] Quantitative Evaluation of Winter Daily Precipitation over Northern Japan

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[MIS01-P09] Seasonal variation of wetland carbon dioxide and methane fluxes measured by automatic chambers at the Bakchar bog, West Siberia

*Shamil Maksyutov[1], Alexandre Fofonov[2], Denis Davydov[2], Oleg Krasnov[2], Tadanobu Nakayama[1], Mikhail Glagolev[3] (1.National Institute for Environmental Studies, 2.V.E. Zuev Institute of Atmospheric Optics, 3.M.V. Lomonosov Moscow State University)

[MIS01-P10] Climatic distances between origin and labor locations for migrants in a changing climate in Siberia by the end of the 21st century

*Elena I. Parfenova[1], Nadezhda M. Tchebakova[1] (1.V.N.Sukachev Institute of Forest SB RAS, FRC SB RAS)

[E] Oral | M (Multidisciplinary and Interdisciplinary) : M-IS Intersection

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 304 3F

[M-IS01] Environmental, socio-economic and climatic changes in Northern Eurasia

convener:Pavel Groisman(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA), Shamil Maksyutov(National Institute for Environmental Studies), Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS), Dmitry A Streletskiy(George Washington University), Chairperson:Shamil Maksyutov(National Institute for Environmental Studies, Japan), Pavel Groisman(NC State University, USA), Yoshihiro Iijima(Mie University, Japan)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS01-01] **Progress and Opportunities in Measurement and Modeling of Arctic Carbon Cycling under a Changing Climate**

★Invited Papers

*Qianlai Zhuang[1], Narasinha Shurpali[2], Torsten Sachs[3] (1.Purdue University, 2.University of Eastern Finland, 3.Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS01-02] Potential climate change effects on biosystems in Siberia by the 2100s predicted from CMIP5

*Nadezhda Tchebakova[1], Elena Parfenova[1], Amber J Soja[2] (1.Sukachev Institute of Forests, Federal Research Center KSC, Siberian Branch, Russian Academy of Sciences, 2.National Institute of Aerospace, NASA Langley Research Center,)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS01-03] Climate Change and Permafrost Degradation in Northern Eurasia: Geographic Impact Assesment

*Dmitry A Streletskiy[1] (1.George Washington University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS01-04] **Effects of deforestation of boreal forests on atmospheric fluxes and weather conditions at the local and regional scales**

*Alexander Olchev[1,2], Vadim Mamkin[2], Inna Rozinkina[3], Yulia Mukhartova[4], Mikhail Nikitin[3], Ekaterina Tatarinovich[3], Julia Kurbatova[2] (1.Lomonosov Moscow State University, Faculty of Geography , 2.A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, 3.Hydrometeorological Research Center of Russian Federation, 4.Lomonosov Moscow State University, Faculty of Physics)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS01-05] **Changes in mountain glacier systems and the distribution of main climatic parameters on the territory of Russia (XX -XXI century)**

*Tatiana Khromova[1], Gennady Nosenko[1], Valeria Popova[1], Anton Muraviev[1], Stanislav Nikitin[1] (1.Institute of Geography Russian Academy of Sciences)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS01-06] Projection of changes in water balance components across irrigated lands of Central Asia using a high-resolution modeling system

*Anastasiia Pikaleva[1], Ekaterina Nadyozhina[1], Alexandra Sternzat[1], Boris Egorov[1], Sergey Efimov[1], Igor Shkolnik[1] (1.Voeikov Main Geophysical Observatory)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 304 3F

[M-IS01] Environmental, socio-economic and climatic changes in Northern Eurasia

convener:Pavel Groisman(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA), Shamil Maksyutov(National Institute for Environmental Studies), Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS), Dmitry A Streletskiy(George Washington University), Chairperson:Dmitry Streletskiy(George Washington University), Pavel Groisman(NC State University, USA), Tetsuya Hiyama(Nagoya University, Japan)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS01-07] **Rises and Falls of the Socioeconomic-Ecological Systems along the Silk Road**

★Invited Papers

*Jiquan Chen[1], Zutao Ouyang[1], Changliang Shao[2], Ranjeet John[1], Geoffrey M Henebry[1], Pavel Groisman[3] (1.Center for Global Changes and Earth Observation, Department of Geography, Environment, and Spatial Sciences, Michigan State University, 2.Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, 3.NC State University Research Scholar, NOAA National Centers for Environment Information)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS01-08] **Interdisciplinary study of the mountain geosystems in the Altay-Sayan region**

*Margarita Syromyatina[1], Yurii Kurochkin[1], Mariia Andreeva[1], Kirill Chistyakov[1] (1.Institute of Earth Sciences, Saint Petersburg State University, Russia)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS01-09] Where in High Mountain Pastures does Snow Seasonality Link Most Closely with Subsequent Land Surface Phenology?

*Geoffrey M Henebry[1], Monika A Tomaszewska[2] (1.Michigan State University, 2.South Dakota State University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS01-10] Evaluation of orographic precipitation over Central Asia and its simulated change under a warming environment

*Akiyo Yatagai[1], Ayano Senda[1], Minami Masuda[1], Vinay Kumar[2] (1.Graduate School of Science and Technology/Hirosaki University, 2.Texas A&M University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS01-11] The impact factor of surface spectral albedo in an arid area

*Jiaxi Yang[1], Zhenchao Li[2], Xiaoqing Gao[2], Panmao Zhai[3] (1.University of Chinese Academy of Sciences, 2.Key Laboratory of Land Surface Process and Climate Change in Cold and Arid Regions, Cold and Arid Regions Environmental and Engineering Research Institute, CAS, Lanzhou, China, 3.Chinese Academy of Meteorological Sciences)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS01-12] **Northern Eurasia Future Initiative (NEFI) Focus on Human-Associated Extreme Events**

*Pavel Groisman[1,2,3], Alexander Shiklomanov[4], Irina Yesserkepova[5], Sergey Gulev[2], Ildan Kaipov[6] (1. NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA, 2. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia , 3. Hydrology Science and Services Corporation, Asheville, North Carolina, USA, 4. University of New Hampshire, Durham, New Hampshire, USA , 5.Joint Stock Company "Zhasyl Damu", Almaty, Kazakhstan, 6. National Center for Space Research and Technologies, Almaty, Kazakhstan)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 301B 3F

[M-IS24] Integrated Analysis of Geoscience Observations from the Floor to Surface of the Ocean

convener:Keisuke Ariyoshi(Japan Agency for Marine-Earth Science and Technology), Motoyuki Kido(International Research Institute for Disaster Science, Tohoku University), Daisuke Inazu(Tokyo University of Marine Science and Technology), Narumi Takahashi(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Keisuke Ariyoshi, Motoyuki Kido

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS24-01] Meteorological Observations at Shionomisaki in cooperation with “Chikyu”, Shinsei-maru and Seisui-maru

*Akira Kuwano-Yoshida[1], Keisuke Ariyoshi[2], Kosei Komatsu[3], Yoshihiro Tachibana[4], Mikiko Fujita[2], Masato I. Nodzu[5], Hatsumi Nishikawa[10], Yoshimi Kawai[2], Naoki Kishita[6], Lyndon Mark Olaguera[5], MIHARU KUBO[8], Kentaro Hase[7], Yuya Matsuyama[6], Minami Masuda[9], Kenta Irie[11], Tetsuji Yoshida[10], Yusuke Watanabe[7], Kosuke Matsuda[12], Syunsuke Aoki[7], Shingo Watanabe[2], Akira Kurisu[13], Shota Yamasaki[7], Hidetaka Hirata[14], Shizuka Akiyama[7], Yoshinori Shigeta[15], Akira Miyata[15], Kai Matsubara[15], Yoshitaka Tada[15], Yasushi Watarai[16], Yusuke Nakamura[16] (1.Disaster Prevention Research Institute, Kyoto University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Graduate School of Frontier Sciences, The University of Tokyo, 4.Faculty of Bioresources, Mie University,, 5.Tokyo Metropolitan University, 6.Kyushu University, 7.Kyoto University, 8.University of The Ryukyus, 9.Hirosaki University, 10.Hokkaido University, 11.Tokyo Gakugei University, 12.Tokyo University of Marine Science and Technology, 13.Okayama University, 14.Nagoya University, 15.Tottori University of Environmental Studies, 16.Rissho University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS24-02] GNSS-A data analysis to estimate the sound speed profile

*Tadashi Ishikawa[1], Yusuke Yokota[2], Shun-ichi Watanabe[1] (1.Hydrographic and Oceanographic Department, Japan Coast Guard, 2.Institute of Industrial Science, the University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS24-03] Comparison of Ocean Bottom Pressure Observation Timeseries with Result of Real Ocean Estimating Models around the Pacific Rim Earthquake Zone

*Yoichiro Dobashi[1], Daisuke Inazu[2] (1.Tokyo University of Marine Science and Technology, 2.Tokyo University of Marine Science and Technology department of marine resouces and energy)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS24-04] Experimental challenges for interpretation of in-situ observation of bottom pressure recorders (BPRs) at the seafloor

★Invited Papers

*Hiroyuki Matsumoto[1], Toshinori Kimura[1], Shuhei Nishida[1], Yuya Machida[1], Eiichiro Araki[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS24-05] Continuous bottom pressure observation by real-time buoy system for tsunami and crustal displacement

*Narumi Takahashi[1], Kentaro Imai[2], Motoyuki Kido[3], Yusaku Ohta[3], Tatsuya Fukuda[2], Yasuhisa Ishihara[2], Hiroshi OCHI[2], Kensuke Suzuki[2], Ryota Hino[3] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Japan Agency for Marine-Earth Science and Technology, 3.Tohoku Univerisity)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS24-06] Looking into the ocean and Earth’s interior from their boundary

★Invited Papers

*Yoshio Fukao[1] (1.CEAT / Japan Agency for Marine-Earth Science & Technology)

[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_25

[M-IS24] Integrated Analysis of Geoscience Observations from the Floor to Surface of the Ocean

convener:Keisuke Ariyoshi(Japan Agency for Marine-Earth Science and Technology), Motoyuki Kido(International Research Institute for Disaster Science, Tohoku University), Daisuke Inazu(Tokyo University of Marine Science and Technology), Narumi Takahashi(National Research Institute for Earth Science and Disaster Resilience)

[MIS24-P01] **A simultaneous observation from seafloor to atmosphere by using “Chikyu” and DONET**

*Keisuke Ariyoshi[1], Takeshi Iinuma[1], Shuhei Nishida[1], Yuya Machida[1], Yasumasa Miyazawa[1], Toru Miyama[1], Hiroshi Uchida[1], Akira Nagano[1], Masahide Wakita[1], Mikiko Fujita[1], Tatsu Kuwatani[1], Amane Fujiwara[1], Katsunori Kimoto[1], Yoshiyuki Nakano[1], Yoshimi Kawai[1], Kaoru Ichikawa[2], Takuya Hasegawa[5], Akira Kuwano-Yoshida[3], Akiko Toh[4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Kyusyu University, 3.Kyoto University, 4.The University of Tokyo, 5.Tohoku University)

[MIS24-P02] Spatio-temporal variation of water pressure on the sea bottom in the Kuroshio region south of Kii Peninsula

*Kosei Komatsu[1,2], Akira Kuwano-Yoshida[3], Keisuke Ariyoshi[4] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3.Disaster Prevention Research Institute, Kyoto University, 4.Japan Agency for Marine-Earth Science and Technology)

[MIS24-P03] GPS-A measurement considering the existence of internal gravity wave

*Motoyuki Kido[1], Ryo Matsui[2], Yoshihiro Niwa[3], Chie Honsho[2] (1.International Research Institute for Disaster Science, Tohoku University, 2.School of Science, Tohoku University, 3.Ocean Alliance, the University of Tokyo)

[MIS24-P04] Measurement of precipitable water vapor using small and lightweight microwave radiometer

*Masahiro Minowa[1], Shigeaki Okumura[1], Shuhei Inoue[1], Yuya Takashima[1], Akira Kuwano-Yoshida[2], Satoru Oishi[3], Toshikazu Onishi[4], Hideo Ogawa[4] (1.FURUNO ELECTRIC CO., LTD., 2.Kyoto Univ., 3.Kobe Univ., 4.Osaka Pref. Univ.)

[MIS24-P05] Observation Across the Large-meander Path of the Kuroshio South of Japan by a Saildrone

★Invited Papers

*Akira Nagano[1], Kentaro Ando[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

[MIS24-P06] Variations in ocean bottom pressure associated with the retreat of the Oyashio current off the southeastern coast of Hokkaido, Japan

*Takuya Hasegawa[1], Akira Nagano[2], Hiroyuki Matsumoto[2], Keisuke Ariyoshi[2], Masahide Wakita[2] (1.Tohoku University, 2.JAMSTEC)

[MIS24-P07] Detection of seafloor crustal deformation from ocean bottom pressure data after applying amplitude corrections on non-tidal components in Hikurangi subduction margin

*Tomohiro Inoue[1], Tomoya Muramoto[2], Daisuke Inazu[3], Yoshihiro Ito[4], Ryota Hino[5], Kazuaki Ohta[4], Syuichi Suzuki[5] (1.Kyoto University, 2.National Institute of Advanced Industrial Science and Technology, 3.Tokyo University of Marine Science and Technology, 4.Disaster Prevention Research Institute, 5.Tohoku University)

[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_41

[M-IS24] Integrated Analysis of Geoscience Observations from the Floor to Surface of the Ocean

convener:Keisuke Ariyoshi(Japan Agency for Marine-Earth Science and Technology), Motoyuki Kido(International Research Institute for Disaster Science, Tohoku University), Daisuke Inazu(Tokyo University of Marine Science and Technology), Narumi Takahashi(National Research Institute for Earth Science and Disaster Resilience)

[MIS24-P01] **A simultaneous observation from seafloor to atmosphere by using “Chikyu” and DONET**

*Keisuke Ariyoshi[1], Takeshi Iinuma[1], Shuhei Nishida[1], Yuya Machida[1], Yasumasa Miyazawa[1], Toru Miyama[1], Hiroshi Uchida[1], Akira Nagano[1], Masahide Wakita[1], Mikiko Fujita[1], Tatsu Kuwatani[1], Amane Fujiwara[1], Katsunori Kimoto[1], Yoshiyuki Nakano[1], Yoshimi Kawai[1], Kaoru Ichikawa[2], Takuya Hasegawa[5], Akira Kuwano-Yoshida[3], Akiko Toh[4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Kyusyu University, 3.Kyoto University, 4.The University of Tokyo, 5.Tohoku University)

[MIS24-P02] Spatio-temporal variation of water pressure on the sea bottom in the Kuroshio region south of Kii Peninsula

*Kosei Komatsu[1,2], Akira Kuwano-Yoshida[3], Keisuke Ariyoshi[4] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3.Disaster Prevention Research Institute, Kyoto University, 4.Japan Agency for Marine-Earth Science and Technology)

[MIS24-P03] GPS-A measurement considering the existence of internal gravity wave

*Motoyuki Kido[1], Ryo Matsui[2], Yoshihiro Niwa[3], Chie Honsho[2] (1.International Research Institute for Disaster Science, Tohoku University, 2.School of Science, Tohoku University, 3.Ocean Alliance, the University of Tokyo)

[MIS24-P04] Measurement of precipitable water vapor using small and lightweight microwave radiometer

*Masahiro Minowa[1], Shigeaki Okumura[1], Shuhei Inoue[1], Yuya Takashima[1], Akira Kuwano-Yoshida[2], Satoru Oishi[3], Toshikazu Onishi[4], Hideo Ogawa[4] (1.FURUNO ELECTRIC CO., LTD., 2.Kyoto Univ., 3.Kobe Univ., 4.Osaka Pref. Univ.)

[MIS24-P05] Observation Across the Large-meander Path of the Kuroshio South of Japan by a Saildrone

★Invited Papers

*Akira Nagano[1], Kentaro Ando[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

[MIS24-P06] Variations in ocean bottom pressure associated with the retreat of the Oyashio current off the southeastern coast of Hokkaido, Japan

*Takuya Hasegawa[1], Akira Nagano[2], Hiroyuki Matsumoto[2], Keisuke Ariyoshi[2], Masahide Wakita[2] (1.Tohoku University, 2.JAMSTEC)

[MIS24-P07] Detection of seafloor crustal deformation from ocean bottom pressure data after applying amplitude corrections on non-tidal components in Hikurangi subduction margin

*Tomohiro Inoue[1], Tomoya Muramoto[2], Daisuke Inazu[3], Yoshihiro Ito[4], Ryota Hino[5], Kazuaki Ohta[4], Syuichi Suzuki[5] (1.Kyoto University, 2.National Institute of Advanced Industrial Science and Technology, 3.Tokyo University of Marine Science and Technology, 4.Disaster Prevention Research Institute, 5.Tohoku University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 301A 3F

[M-IS25] Recent weather disasters: factors and impact on the atmosphere, hydrosphere, and human beings

convener:Kazuaki Nishii(Graduate School of Bioresources, Mie University), Chairperson:Kazuaki Nishii(三重大学)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS25-01] Heavy Rainfall Event in Middle Viet Nam on 8-9 December 2018 and current QPE/QPF at VNMHA

★Invited Papers

*Kazuo Saito[1,2,3], Le Duc[4,3], Du Duc Tien[5], Mai Khanh Hung[5] (1.Japan Meteorological Business Suport Center, 2.Atmosphere and Ocean Research Institute, the University of Tokyo, 3.Meteorological Research Institute, 4.Japan Agency for Marine-Earth Science and Technology, 5.National Center for Hydro-Meteorological Forecasting, Viet Nam Meteorological and Hydrological Administration)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS25-02] High-resolution flow-simulation in Typhoon 21, 2018: tremendous loss of water plants in South Lake Biwa

★Invited Papers

*Satoshi Nakada[1], Hiroki Haga[2], Maho Iwaki[1], Keisuke Hatano[3], Koji Mabuchi[1], Noriko Takamura[1] (1.National Institute for Environmental Studies, 2.Lake Biwa Museum, 3.Japan Water Agency)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS25-03] Northern mid-latitude warming prolonged for more than 6 months in 2018 well-predicted by the JMA's operational seasonal prediction system

*Chiaki Kobayashi[1], Ichiro Ishikawa[1] (1.Meteorological Research Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS25-04] Synoptic-scale Predictability of Heavy Rain over Western Japan in July 2018

*Akira Kuwano-Yoshida[1] (1.Disaster Prevention Research Institute, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS25-05] Anomalous Moisture Transport and Oceanic Evaporation during a Torrential Rainfall Event over Western Japan in Early July 2018

*Shion Sekizawa[1], Takafumi Miyasaka[1,2], Hisashi Nakamura[1], Akihiko Shinpo[3], Kazuto Takemura[3], Shuhei Maeda[3] (1.Research Center for Advanced Science and Technology, University of Tokyo, 2.Meteorological Research Institute, 3.Japan Meteorological Agency)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS25-06] Leading modes of atmospheric circulation variability during the heavy rain event in July 2018

*Kazuaki Nishii[1], Bunmei Taguchi[2], Hisashi Nakamura[2] (1.Graduate School of Bioresources, Mie University, 2.Research Center for Advanced Science and Technology, The University of Tokyo)

[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_26

[M-IS25] Recent weather disasters: factors and impact on the atmosphere, hydrosphere, and human beings

convener:Kazuaki Nishii(Graduate School of Bioresources, Mie University)

[MIS25-P01] Environmental Factors affecting 2018 Western North Pacific Tropical Cyclone Activity

★Invited Papers

*Satoshi Iizuka[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[MIS25-P02] **Impact of the Japan/East Sea on the heavy rain event of July 2018 in Japan**

*ATSUYOSHI MANDA[1], Satoshi Iizuka[3], Tkafumi Miyasaka[2,4,5], Hisashi Nakamura[2] (1.Mie University, 2.The University of Tokyo, 3.National Research Institute for Earth Science and Disaster Resilience, 4.Japan Meteorological Agency, Meteorological Research Institute, 5.Japan Meteorological Business Support Center)

[MIS25-P03] Simple sensitivity analysis using weekly ensemble forecasts during the heavy rain event in July 2017

*Yoshimi Kawai[1] (1.Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology)

[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_42

[M-IS25] Recent weather disasters: factors and impact on the atmosphere, hydrosphere, and human beings

convener:Kazuaki Nishii(Graduate School of Bioresources, Mie University)

[MIS25-P01] Environmental Factors affecting 2018 Western North Pacific Tropical Cyclone Activity

★Invited Papers

*Satoshi Iizuka[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[MIS25-P02] **Impact of the Japan/East Sea on the heavy rain event of July 2018 in Japan**

*ATSUYOSHI MANDA[1], Satoshi Iizuka[3], Tkafumi Miyasaka[2,4,5], Hisashi Nakamura[2] (1.Mie University, 2.The University of Tokyo, 3.National Research Institute for Earth Science and Disaster Resilience, 4.Japan Meteorological Agency, Meteorological Research Institute, 5.Japan Meteorological Business Support Center)

[MIS25-P03] Simple sensitivity analysis using weekly ensemble forecasts during the heavy rain event in July 2017

*Yoshimi Kawai[1] (1.Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology)

[E] Oral | M (Multidisciplinary and Interdisciplinary) : M-GI General Geosciences, Information Geosciences & Simulations

9:00 AM - 10:30 AM JST | 12:00 AM - 1:30 AM UTC | 302 3F

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), Chairperson:Yasuhiro Murayama(NICT)

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MGI31-01] WDS: International Coordination for Sustainable FAIR Data, for Science and Society

*Yasuhiro Murayama[1] (1.Strategic Program Produce Office, National Institute of Information and Communications Technology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MGI31-02] Japan Data Repository Network (JDARN): Community-based activities for improving the trustworthiness of data repositories

*Asanobu Kitamoto[1,2,4], Hiroko Kinutani[3] (1.National Institute of Informatics, 2.ROIS-DS Center for Open Data in the Humanities, 3.EDITORIA, The University of Tokyo, 4.SOKENDAI)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MGI31-03] Data Sharing and Open Science: Practice, Expectation, Transparency, and Credit

*Shelley Stall[1] (1.American Geophysical Union)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MGI31-04] Ethical issues in open science

*Yasuhisa Kondo[1] (1.Research Institute for Humanity and Nature)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MGI31-05] The perspective of Open Science with consideration of the gap between the Integrated Innovation Strategy and the current state of scholarly communication

*Kazuhiro Hayashi[1] (1.National Institute of Science and Technology Policy)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MGI31-06] Future evolution of open archives for preprints, posters, and presentations as a key component of open science in the Earth and space sciences

*Brooks Hanson[1] (1.American Geophysical Union)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | 302 3F

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), Chairperson:Shelley Stall(American Geophysics Union)

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MGI31-07] Cloud Computing Needs for Earth Observation Data Analysis: EGI and the European Open Science Cloud

★Invited Papers

Björn Backeberg[1], Yin Chen[1], *Tiziana Ferrari[1], Pedro Gonçalves[4], Paolo Mazzetti[3], Anabela Oliveira[2], Diego Scardaci[1], Gergely Sipos[1] (1.EGI Foundation, 2.LNEC, 3.CNR, 4.Terradue)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MGI31-08] Open third generation geostationary satellites accelerate environmental studies: Case studies of CEReS, Chiba University, Japan

*Atsushi Higuchi[1,3], Koichi Toyoshima[1], Hitoshi Hirose[1], Hideaki Takenaka[2,1] (1.Center for Environmental Remote Sensing (CEReS), Chiba University, Japan, 2.EORC, JAXA, 3.NICT)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MGI31-09] Scientific data chain for better data publication and preservation

*Takeshi Horinouchi[1] (1.Faculty of Environmental Earth Science, Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MGI31-10] Current status and problems of geodetic observation data distribution

*Toshimichi Otsubo[1], Yusuke Yokota[2], Tadashi Ishikawa[3], Mamoru Sekido[4], Takayuki Miyazaki[5], Shinobu Kurihara[5] (1.Hitotsubashi University, 2.Institute of Industrial Science, the University of Tokyo, 3.Hydrographic and Oceanographic Department, Japan Coast Guard, 4.National Institute of Information and Communications Technology, 5.Geospatial Information Authority of Japan)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MGI31-11] Recent activity of data publication and data citation in the international community of geomagnetism

*Masahito Nose[1], Yasuhiro Murayama[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Strategic Program Produce Office, National Institute for Information Communications Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MGI31-12] IGSN: International Collaboration Makes Samples and Sample Data FAIR

*Kerstin Lehnert[1], Jens Klump[2], Lesley Wyborn[3], Sarah Ramdeen[4] (1.Columbia University, 2.CSIRO Kensington, Australia, 3.Australian National University, Canberra, Australia, 4.Ronin Institute, USA)

[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_7

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University)

[MGI31-P01] Open Science, Community Science, and AGU's Thriving Earth Exchange.

*Shelley Stall[1], Raj Pandya[1] (1.American Geophysical Union)

[MGI31-P02] RDUF (Research Data Utilization Forum): an arena for community discussion of international and regional research data sharing and management

Hideaki Takeda[2], *Yasuhiro Murayama[1], RDUF secretary office[3] (1.Strategic Program Produce Office, National Institute of Information and Communications Technology, 2.National Institute of Informatics, 3.Japan Science and Technology Agency)

[MGI31-P03] Query string-controlled web service for sharable and reproducible data visualization of earth, planetary and space sciences

*Koji Imai[1], Yasuhiro Murayama[1] (1.National Institute of Information and Communications Technology)

[MGI31-P04] Development of ground pipeline system for high-level scientific data products of the Hisaki satellite mission and its application to planetary space weather

*Tomoki Kimura[1], Atsushi Yamazaki[2], Kazuo Yoshioka[3], Go Murakami[2], Fuminori Tsuchiya[4], Hajime Kita[2], Chihiro Tao[5], Ichiro Yoshikawa[3], Atsushi Kumamoto[6], Yamauchi Chisato[7] (1.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Department of Complexity Science and Engineering, University of Tokyo, 4.Planetary Plasma and Atmospheric Research Center, Tohoku University, 5.National Institute of Information and Communications Technology, 6.Space and Terrestrial Plasma Physics Laboratory, Tohoku University, 7.Misato Observatory)

[MGI31-P05] Recent activities of the IUGONET for accelerating the integrated solar terrestrial science

*Shuji Abe[1], Yoshimasa Tanaka[2], Norio Umemura[3], Atsuki Shinbori[3], Satoru UeNo[4], Masahito Nose[3] (1.International Center for Space Weather Science and Education, Japan, 2.National Institute of Polar Research, 3.Institute for Space-Earth Environmental Research, Nagoya University, 4.Kwasan & Hida Observatories, School of Science, Kyoto University)

[MGI31-P06] Attempt for Research Data Sharing and Citation in context of Open Science - Sharing Atmospheric MF Radar Observation Database as a Case Study

*Isoda Fusako[1], Yasuhiro Murayama[1], Koji Imai[1] (1.National Institute of Information and Communications Technology)

[MGI31-P07] A case example of sharing meteor radio observational data by small laboratory

*Yukinobu Koyama[1], Yusuke Miyanari[1] (1.National Institute of Technology, Oita College)

[MGI31-P08] Promotion of an Open-Science Activity of the Earth Science - Coordinated Observations and Data Analyses of meteor-associated Low-Frequency Radio Emission and Anomalous Hearing

*Takashi Watanabe[1] (1.ISC World Data System International Programme Office)

[MGI31-P09] Current status of minting DOIs for research data in JAMSTEC

*Kazuyo Fukuda[1], Hajime Kawakami[1], Tomoki Sasaki[1], Hiroki Horikawa[1], Hideaki Saito[1], Chizuru Saito[1], Sonoda Akira[1] (1.Japan Agency for Marine-Earth Science and Technology)

[MGI31-P10] Application of Web and GIS Technology to Develop Military's Differential Action Information Platform

*Chien Hao Chang[1], Ch Yu Liu[1], Chun Ta Wei[1] (1.Department of Computer Science and Information Engineering,CCIT)

[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_43

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University)

[MGI31-P01] Open Science, Community Science, and AGU's Thriving Earth Exchange.

*Shelley Stall[1], Raj Pandya[1] (1.American Geophysical Union)

[MGI31-P02] RDUF (Research Data Utilization Forum): an arena for community discussion of international and regional research data sharing and management

Hideaki Takeda[2], *Yasuhiro Murayama[1], RDUF secretary office[3] (1.Strategic Program Produce Office, National Institute of Information and Communications Technology, 2.National Institute of Informatics, 3.Japan Science and Technology Agency)

[MGI31-P03] Query string-controlled web service for sharable and reproducible data visualization of earth, planetary and space sciences

*Koji Imai[1], Yasuhiro Murayama[1] (1.National Institute of Information and Communications Technology)

[MGI31-P04] Development of ground pipeline system for high-level scientific data products of the Hisaki satellite mission and its application to planetary space weather

*Tomoki Kimura[1], Atsushi Yamazaki[2], Kazuo Yoshioka[3], Go Murakami[2], Fuminori Tsuchiya[4], Hajime Kita[2], Chihiro Tao[5], Ichiro Yoshikawa[3], Atsushi Kumamoto[6], Yamauchi Chisato[7] (1.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Department of Complexity Science and Engineering, University of Tokyo, 4.Planetary Plasma and Atmospheric Research Center, Tohoku University, 5.National Institute of Information and Communications Technology, 6.Space and Terrestrial Plasma Physics Laboratory, Tohoku University, 7.Misato Observatory)

[MGI31-P05] Recent activities of the IUGONET for accelerating the integrated solar terrestrial science

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[MGI31-P10] Application of Web and GIS Technology to Develop Military's Differential Action Information Platform

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[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), Chairperson:Baptiste Cecconi(LESIA - Observatoire de Paris)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MGI31-13] Adoption of IGSN in the International Ocean Discovery Program (IODP)

*Sean Toczko[1] (1.Japan Agency for Marine-Earth Science and Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MGI31-14] Oceanogrpahic Data and Information Exchange for Open Science

*Toru Suzuki[1] (1.Marine Information Research Center)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI31-15] The International Heliophysics Data Environment Alliance (IHDEA) initiative

★Invited Papers

*Arnaud Masson[1], Aaron Roberts[2], Shing Fung[2], Bob McGuire[2], Jack Ireland[2], Jeremy Faden[12], Jim Lewis[9], Baptiste Cecconi[7], Vincent Genot[8], J.C. Malapert[4], Keiichi Matsuzaki[3], Todd King[5], Daniel Mueller[6], Jon Vandegriff[10], Miyoshi Yoshizumi[11] (1.ESAC Science Data Center, European Space Agency, Madrid, Spain, 2.NASA/GSFC, USA, 3.JAXA, ISAS, Tokyo, 4.CNES, Toulouse, 5.UCLA, USA, 6.ESTEC, European Space Agency, Noordwijk, The Netherlands, 7.LESIA, Observatoire de Paris, France, 8.IRAP, CNRS, Toulouse, 9.Berkeley University, USA, 10.John Hopkins, APL, USA, 11.ISEE, Nagoya University, Nagoya 464-8601, Japan, 12.Cottage Systems, University of Iowa, USA)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI31-16] **VESPA: Progress on the Planetary Science Virtual Observatory**

*Stephane Erard[1] (1.Observatoire de Paris / LESIA)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI31-17] Publishing planetary science data following FAIR principles

*pierre le sidaner[1], Baptiste Cecconi[2], Stephane Erard[2], Cyril Chauvin[1], Albert Shih[1], Stephane Aicardi[1], Philippe Hamy[1], Alan Loh[2] (1.DIO - Observatoire de Paris, Universite PSL, CNRS UMS2201, 2.LESIA, Observatoire de Paris, Universite PSL, CNRS, Sorbonne Université, Univ. Paris Diderot, Sorbonne Paris Cite)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI31-18] Community-developed open tools for supporting the ESA JUICE space mission preparation

*Baptiste Cecconi[1], Alan Loh[1], Stephane Aicardi[2], Corentin Louis[3] (1.LESIA, Observatoire de Paris, CNRS, PSL Research University, Meudon, France, 2.DIO, Observatoire de Paris, CNRS, PSL Research University, Paris, France, 3.IRAP, CNRS-Université Paul Sabatier, Toulouse, France)

[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_27

[M-GI32] Collaboration and Co-creation of Geoscience, Art and Design

convener:kubo takashi(MAIBUNKAN), Noriko SHIRAISHI(Department of Earth and Planetary Craft)

[MGI32-P01] **Photography in geomorphology**

*Yuichi S. Hayakawa[1] (1.Faculty of Environmental Earth Science, Hokkaido University)

[MGI32-P02] Co-create Expression of the Earth Science with an Art museum and artist and Natural history museum.

*kubo takashi[1], chikako syakudo[2] (1.MAIBUNKAN, 2.Kurobe City Art Museum)

[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_44

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_10

[M-GI37] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University)

[MGI37-P01] Publication of georeferenced polygon data to make JMA XML machine-readable

*Eizi TOYODA[1] (1.Administration Department, Japan Meteorological Agency)

[MGI37-P02] Development of a web system for search, browsing and download of Akatsuki's observation data

*Ko-ichiro SUGIYAMA[1], Kosei Murakoso[1], Kazuki Oomori[1,3], Takumi Aoki[1,4], Shin-ya Murakami[2] (1.National Institute of Technology, Matsue College, 2.ISAS/JAXA, 3.NTT DATA MHI Systems Corporation, 4.Mazda E&T)

[MGI37-P03] Large amount of data related to D/V Chikyu and science support activities

*Yukari Kido[1], Takamitsu Sugihara[1], Yoshinori Sanada[1], Tatsuya Murayama[1] (1.Japan Agency for Marine-Earth Science and Technology)

[MGI37-P04] Data delivery and visualization service for climate forecast data in the Arctic Ocean during R/V Mirai cruise MR18-05

*Takeshi Terui[1], Takeshi Sugimura[1], Liyanarachchi Waruna Arampath De Silva[2], Souichiro Sueyoshi[3], Jun Inoue[1] (1.National Institute of Polar Research, 2.The University of Tokyo, 3.Nippon Marine Enterprises)

[MGI37-P05] Improvement of mineral mapping accuracy by increasing spectral band and spatial resolutions of multispectral optical sensor imagery

*Katsuaki Koike[1], Nguyen Tien Hoang[1], Shuho Noda[2], Yukie Asano[2], Yuu Kawakami[2], Kazuo Masuda[2] (1.Laboratory of Environmental Geosphere Engineering, Department of Urban Management, Graduate School of Engineering, Kyoto University, 2.Japan Oil, Gas and Metals National Corporation (JOGMEC))

[MGI37-P06] Analysis of vessel status information of past research cruises and prediction of downtime for future cruise

*Yasuko Yamagishi[1], Ken Yatsu[2], Kazuhiko Kashiwase[2], Tetsuji Maki[2], Yuta Yamamuro[2,3], Hide Sakaguchi[1] (1.MAT, JAMSTEC, 2.MARITEC, JAMSTEC, 3.Nippon Marine Enterprises, Ltd.)

[MGI37-P07] Verification of an ocean monitoring system using a climate satellite "Himawari"

*YUUICHI KAGA[1], SHIGETO WATANABE[1] (1.Hokkaido Information University)

[MGI37-P08] Development of smooth area detection method for selection of landing site on a small body

Yuki Fujii[1], *Rie Honda[1], Tomokatsu Morota[4], yokota yasuhiro[2], ERI TATSUMI[3], Naoya Sakatani[2], Manabu Yamada[9], Shingo Kameda[5], Toru Kouyama[10], Hidehiko Suzuki[6], Chikatoshi Honda[7], Masahiko Hayakawa[2], Kazuo Yoshioka[3], Yuichiro Cho[3], Yukio Yamamoto[2], Naru Hirata[7], Naoyuki Hirata[8], Hirotaka Sawada[2], Seiji Sugita[3] (1.Kochi University, 2.ISAS/JAXA, 3.University of Tokyo, 4.Nagoya University, 5.Rikkyo University, 6.Meiji University, 7.Aizu University, 8.Kobe University, 9.Chiba Institute of Technology, 10.National Institute of Advanced Industrial Science and Technology)

[MGI37-P09] Activity Report of Hackathon Event "SpaceHack 2019" for Utilization of Space Data

*Tsubasa Yumura[1], Satoshi Kikuchi[1], Tsutomu Nagatsuma[1], Ken T. Murata[1] (1.National Institute of Information and Communications Technology)

[MGI37-P10] Experimental Evaluation of High-Speed File Transfer over JHPCN

*Praphan Pavarangkoon[1], Ken T. Murata[1], Kazunori Yamamoto[1], Takamichi Mizuhara[2], Yuya Kagebayashi[2], Ayahiro Takaki[2], Kazuya Muranaga[3], Keiichiro Fukazawa[4] (1.National Institute of Information and Communications Technology, Tokyo, Japan, 2.CLEALINK TECHNOLOGY Co., Ltd., Kyoto, Japan, 3.Systems Engineering Consultants Co., Ltd., Tokyo, Japan, 4.Academic Center for Computing and Media Studies, Kyoto University, Kyoto, Japan)

[MGI37-P11] Programming Environment of Visual IoT Tools Working on Single-Board Computer (Raspberry Pi) (2)

*Takamichi Mizuhara[1], Ken T. Murata[2], Praphan Pavarangkoon[2], Somnuk Phon-Amnuaisuk[3], Kazunori Yamamoto[2], Kazuya Muranaga[4], Toshiki Aoki[1] (1.CLEALINK TECHNOLOGY CO., LTD., 2.National Institute of Information and Communications Technology, 3.Universiti Teknologi Brunei, 4.Systems Engineering Consultants Co., LTD.)

[MGI37-P12] Real-Time Monitoring Technique of Earth Environment via Visual IoT

*Kazunori Yamamoto[1], Ken T. Murata[1], Takamichi Mizuhara[2], Praphan Pavarangkoon[1], Kazuya Muranaga[3], Toshiki Aoki[2] (1.National Institute of Information and Communications Technology, 2.CLEALINK TECHNOLOGY Co., Ltd., 3.Systems Engineering Consultants Co.,LTD.)

[MGI37-P13] International Deployment of real-time web of Himawari (meteorological satellite) data: A case of mirroring to Philippines

Kazuya Muranaga[1], Praphan Pavarangkoon[2], Kazunori Yamamoto[2], *Ken T. Murata[2], Atsushi Higuchi[3] (1.Systems Engineering Consultants Co., LTD., 2.National Institute of Information and Communications Technology, 3.Chiba University)

[MGI37-P14] Visualization of Himawari-8 observation data using high resolution animation: The case studies of CEReS, Chiba University, Japan

*Koichi Toyoshima[1], Atsushi Higuchi[1] (1.Center for Environmental Remote Sensing, Chiba University)

[MGI37-P15] Performance evaluation of inter-node MPI parallel TensorFlow for massive learning data

*Keiichiro Fukazawa[1] (1.Academic Center for Computing and Media Studies, Kyoto University)

[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_45

[M-GI37] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University)

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[MGI37-P05] Improvement of mineral mapping accuracy by increasing spectral band and spatial resolutions of multispectral optical sensor imagery

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[MGI37-P06] Analysis of vessel status information of past research cruises and prediction of downtime for future cruise

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[MGI37-P07] Verification of an ocean monitoring system using a climate satellite "Himawari"

*YUUICHI KAGA[1], SHIGETO WATANABE[1] (1.Hokkaido Information University)

[MGI37-P08] Development of smooth area detection method for selection of landing site on a small body

Yuki Fujii[1], *Rie Honda[1], Tomokatsu Morota[4], yokota yasuhiro[2], ERI TATSUMI[3], Naoya Sakatani[2], Manabu Yamada[9], Shingo Kameda[5], Toru Kouyama[10], Hidehiko Suzuki[6], Chikatoshi Honda[7], Masahiko Hayakawa[2], Kazuo Yoshioka[3], Yuichiro Cho[3], Yukio Yamamoto[2], Naru Hirata[7], Naoyuki Hirata[8], Hirotaka Sawada[2], Seiji Sugita[3] (1.Kochi University, 2.ISAS/JAXA, 3.University of Tokyo, 4.Nagoya University, 5.Rikkyo University, 6.Meiji University, 7.Aizu University, 8.Kobe University, 9.Chiba Institute of Technology, 10.National Institute of Advanced Industrial Science and Technology)

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[MGI37-P10] Experimental Evaluation of High-Speed File Transfer over JHPCN

*Praphan Pavarangkoon[1], Ken T. Murata[1], Kazunori Yamamoto[1], Takamichi Mizuhara[2], Yuya Kagebayashi[2], Ayahiro Takaki[2], Kazuya Muranaga[3], Keiichiro Fukazawa[4] (1.National Institute of Information and Communications Technology, Tokyo, Japan, 2.CLEALINK TECHNOLOGY Co., Ltd., Kyoto, Japan, 3.Systems Engineering Consultants Co., Ltd., Tokyo, Japan, 4.Academic Center for Computing and Media Studies, Kyoto University, Kyoto, Japan)

[MGI37-P11] Programming Environment of Visual IoT Tools Working on Single-Board Computer (Raspberry Pi) (2)

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[MGI37-P12] Real-Time Monitoring Technique of Earth Environment via Visual IoT

*Kazunori Yamamoto[1], Ken T. Murata[1], Takamichi Mizuhara[2], Praphan Pavarangkoon[1], Kazuya Muranaga[3], Toshiki Aoki[2] (1.National Institute of Information and Communications Technology, 2.CLEALINK TECHNOLOGY Co., Ltd., 3.Systems Engineering Consultants Co.,LTD.)

[MGI37-P13] International Deployment of real-time web of Himawari (meteorological satellite) data: A case of mirroring to Philippines

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[MGI37-P14] Visualization of Himawari-8 observation data using high resolution animation: The case studies of CEReS, Chiba University, Japan

*Koichi Toyoshima[1], Atsushi Higuchi[1] (1.Center for Environmental Remote Sensing, Chiba University)

[MGI37-P15] Performance evaluation of inter-node MPI parallel TensorFlow for massive learning data

*Keiichiro Fukazawa[1] (1.Academic Center for Computing and Media Studies, Kyoto University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 301B 3F

[M-GI37] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University), Chairperson:Susumu Nonogaki, Ken Murata(National Institute of Information and Communications Technology)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MGI37-01] Exploration of the earth environment using meteorological satellite "Himawari"

*ryuta ando[1], Shigeto Watanabe[1], Ken T. Murata[2] (1.Hokkaido Information University, 2.National Institute of Information and Communications Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MGI37-02] Kochi radar network composed of compact X-band radars

*Koji Sassa[1], Toshiaki Takaki[2], Ken T Murata[3] (1.Natural Science Cluster, Kochi University, 2.Furuno Electric Co.,Ltd., 3.National Institute of Information and Communication Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MGI37-03] Rain Echo Classification by Deep Learning Using Observation Big Data of Phased Array Weather Radar

*Shinsuke Satoh[1], Hiroshi HANADO[1], Seiji Kawamura[1], Tomohiko Konno[1], Michiaki Iwazume[1], Shigenori Otsuka[2], Takemasa Miyoshi[2] (1.National Institute of Information and Communications Technology, 2.RIKEN Center for Computational Science)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MGI37-04] Communication area map of LoRa in Chikuma city using community bus services

*Kohei Mizuani[1], Ken T. Murata[1], Yoshiaki Muroyama[1], Kazunori Yamamoto[1], Kazuya Muranaga[2], Takamichi Mizuhara[3], Praphan Pavarangkoon[1] (1.National Institute of Information and Communications Technology, 2.Systems Engineering Consultants Co., LTD., 3.CLEALINK TECHNOLOGY Co.,Ltd.)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MGI37-05] Development of an inexpensive and small balloon observation device, and its application in observing the Earth's upper atmosphere

*Taku Takada[1], Yui Sasaoka[1], Shiya Ueta[1], Ken T. Murata[2], Hidehiko Suzuki[3] (1.National Institute of Technology, Kochi College, 2.National Institute of Information and Communications Technology, 3.Meiji University)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 301B 3F

[M-GI37] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University), Chairperson:Rie Honda, Ken Murata(National Institute of Information and Communications Technology)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MGI37-06] Introduction of “ChOWDER”: A tiled display driver that augment large scale visualization of geoscience.

*Tomohiro Kawanabe[1], Kenji Ono[2], Atsushi Higuchi[3], Koichi Toyoshima[3], Kazunori Yamamoto[4], Kazuya Muranaga[5], Ken T. Murata[4] (1.RIKEN , 2.Kyushu Univ., 3.Chiba Univ., 4.NICT, 5.Systems Engineering Consultants Co.,LTD.)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MGI37-07] Data archive and integrated data analysis tools developed by ERG Science Center

*Tomoaki Hori[1], Yoshizumi Miyoshi[1], Masafumi Shoji[1], Mariko Teramoto[1], Tzu-Fang Chang[1], Satoshi Kurita[1], Shoya Matsuda[2], Yasunori Tsugawa[1], Tomonori Segawa[1], Norio Umemura[1], Nozomu Nishitani[1], Takako Kondo[1], Hiroyasu Yonaha[1], Yukinaga Miyashita[3], Kunihiro Keika[4], Kanako Seki[4], Yoshimasa Tanaka[5], Iku Shinohara[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Japan Aerospace Exploration Agency / Institute of Space and Astronautical Science, 3.Korea Astronomy and Space Science Institute, 4.Graduate School of Science, The University of Tokyo, 5.National Institute of Polar Research)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI37-08] KOSEN-1 CubeSat mission for Jupiter's radio science

*Kazumasa Imai[1], Nobuto Hirakoso[2], Taku Takada[1], Kentarou Kitamura[3], Masafumi Imai[4], KOSEN-1 Team[5], Charles A. Higgins[6], James R. Thieman[7], NASA Radio JOVE Team[8] (1.Department of Social Design Engineering, National Institute of Technology, Kochi College, 2.Department of Mechanical Engineering, National Institute of Technology, Gunma College, 3.Department of Mechanical and Electrical Engineering, National Institute of Technology, Tokuyama College, 4.University of Iowa, 5.KOSEN-1 Team, 6.Middle Tennessee State University, 7.University of Maryland Baltimore County, 8.NASA Radio JOVE Team)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI37-09] Problems of acquisition of auroral image data and data processing

*Ryuho Kataoka[1], Ken T. Murata[2], Yoshizumi Miyoshi[3], Herbert Akihito Uchida[1], Yoko Fukuda[4], Atsushi Yamashita[5], Masayuki Tanaka[6] (1.National Institute of Polar Research, 2.National Institute of Information and Communication Technology, 3.Nagoya University, 4.National Institute for Environmental Studies, 5.The University of Tokyo, 6.Tokyo Institute of Techonology)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI37-10] Innovative progress in ground observation of snow crystals and weather conditions by citizen science

★Invited Papers

*Kentaro Araki[1] (1.Meteorological Research Institute)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI37-11] Efforts of landslide susceptibility mapping for slope disaster risk evaluation

*Kazunori Hayashi[1], Akihiko Wakai[2], Go Sato[3], Takashi Kimura[4], Ken T. Murata[5], Akino Watanabe [2] (1.Okuyama Boring Co., Ltd., 2.Gunma University, 3.Teikyo Heisei University, 4.National Research Institute for Earth Science and Disaster, 5.National Institute of Information and Communications Technology)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 302 3F

[M-AG41] Dynamics of radionuclides emitted from Fukuchima Dai-ichi Nuclear Power Plant in the environment

convener:Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Daisuke Tsumune(Central Research Institute of Electric Power Industry), Chairperson:Yoshio Takahashi(東京大学), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MAG41-01] Investigation on basic physical and chemical properties of radio-Cs micro particles

*Yasuhito Igarashi[1], Kazuyuki Kita[2], Yukihiko Satou[3], Tomoaki Okuda[4], Yoshinari Abe[5], Keisuke Sueki[6], SHINOHARA ATSUSHI[7], Kazuhiko Ninomiya[7], Tsutomu Ohtshuki[1], Koichi Takamiya[1] (1.Institute for Integrated Radiation and Nuclear Science, Kyoto University, 2.Graduate School of Science and Engineering, Ibaraki University, 3.Collaborative Laboratories for Advanced Decommissioning Science, Japan Atomic Energy Agency, 4.Department of Applied Chemistry, Keio University, 5.Faculty of Science,Tokyo University of Science, 6.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, 7.Graduate School of Science, Osaka University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MAG41-02] Dynamics of radioactive microparticles released from the Fukushima nuclear plant: heating and dissolution characteristics

★Invited Papers

*Taiga Okumura[1], Noriko Yamaguchi[2], Terumi Dohi[3], Kenso Fujiwara[3], Kazuki Iijima[3], Toshihiro Kogure[1] (1.The University of Tokyo, 2.National Agriculture and Food Research Organization, 3.Japan Atomic Energy Agency)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MAG41-03] Dynamics of atmospheric ^{131}I just after the Fukushima accident related to ^{137}Cs by analysis of published data

*Haruo Tsuruta[1], Yuichi Moriguchi[2], Teruyuki Nakajima[3] (1.Remote Sensing Technology Center of Japan, 2.The University of Tokyo, 3.Japan Aerospace Exploration Agency)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MAG41-04] Distribution of ^{237}Np and Plutonium isotope in terrestrial environment in Fukushima Prefecture

*Miho Fukuda[1], Zheng Jian[1], yamazaki Shinnnosuke[1], Tatsuo Aono[1] (1.National Institute for Quantum and Radiological Science and Technology, National Institute of Radiological Science)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MAG41-05] Study on deposition of ^{134}Cs and ^{137}Cs from atmosphere to freshwater environment using a mountainous lake, Lake Haruna in Gunma Prefecture, Japan

*Seiya Nagao[1], Shouhei Miyasaka[2], Shun Watanabe[3], Kyuma Suzuki[3], Shinya Ochiai[1] (1.Institute of Nature and Environmental Technology, Kanazawa University, 2.Graduate School of Natural Science and Technology, Kanazawa University, 3.Gunma Prefectural Fisheries Experimental Station)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MAG41-06] Spatial variability of radiocesium deposition through the tree canopy via branchflow and stemflow

*Zul Hilmi Saidin[1], Yuichi Onda[2], Hiroaki Kato[2], Momo Kurihara[2], Kazuki Nanko[3], Delphis F. Levia[4] (1.Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba, Ibaraki, Japan, 2.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, Tsukuba, Ibaraki, Japan, 3.Department of Disaster Prevention, Meteorology and Hydrology, Forestry and Forest Products Research Institute, Tsukuba, Ibaraki, Japan, 4.Departments of Geography, University of Delaware, Newark, Delaware, USA)

[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 302 3F

[M-AG41] Dynamics of radionuclides emitted from Fukuchima Dai-ichi Nuclear Power Plant in the environment

convener:Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Daisuke Tsumune(Central Research Institute of Electric Power Industry), Chairperson:Kazuyuki Kita(Ibaraki University), Daisuke Tsumune(Central Research Institute of Electric Power Industry)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MAG41-07] Temporal changes in vertical distributions of radiocesium in forest soils after the FDNPP accident

★Invited Papers

*Junko Takahashi[1], Daichi Hihara[1], Takuya Sasaki[1], Yuichi Onda[1] (1.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MAG41-08] Change of sediment sources in suspended sediments due to surface decontamination in the Niida river catchment area affected by the Fukushima Daiichi nuclear power plant accident

*Yuichi Onda[1], Yuki Yamanaka[1], Yoshifumi Wakiyama[2], Keisuke Taniguchi[3], Takaaki Kubo[1] (1.Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba, 2.Institute of Environmental Radioactivity, Fukushima University, 3.Fukushima Prefectural Centre for Environmental Creation)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MAG41-09] Neasrshore transport of suspended radiocesium In the Fuksima Coast derived from Niida River induced by Typhoon Wipha

*Natsuki Tokunaga[1], Yusuke Uchiyama[1], Daisuke Tsumune[2], Masatoshi Yamada[5], Yutaka Tateda[2], Yukari Ito[3], Takashi Ishimaru[3], Yutaka Watanabe[7], Ken Ikehara[4], Miho Fukuda[6] (1.Kobe University, 2.Central Research Institute of Electric Power Industry, 3.Tokyo University of Marine Science and Technology, 4.National Institute of Advanced Industrial Science and Technology, 5.Hirosaki University, 6.National Institute of Radiological Sciences, 7.Hokkaido University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MAG41-10] Particle size distribution and radiocesium concentration in suspended particles within the high turbidity layer at near sea bottom off Fukushima prefecture

*Hideki Kaeriyama[1], Naoki Furuichi[2], Kouichi Sugimatsu[3], Yuya Shigenobu[1], Shizuho Miki[1], Takami Morita[1], Daisuke Ambe[1], Tadafumi Ichikawa[1] (1.National Research Institute of Fisheries Science, Japan Fisheries Research and Education Agency, 2.National Research Institute of Fisheries Engineering, Japan Fisheries Research and Education Agency, 3.Seikai National Research Institute, Japan Fisheries Research and Education Agency)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MAG41-11] Fukushima-derived radiocesium in the subarctic region of the North Pacific Ocean in the summer of 2017

★Invited Papers

*Yuichiro Kumamoto[1], Michio Aoyama[2], Yasunori Hamajima[3], Akihiko Murata[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Fukushima University, 3.Kanazawa University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MAG41-12] **Temporal and spatial variations of radiocaesium in the East China Sea and Sea of Japan until 2018**

*Michio Aoyama[1], Yayoi Inomata[2], Yasunori Hamajima[2] (1.Institute of Environmnetal Radioactivity, Fukushima University, 2.Institute of Nature and Environmental Technology, Kanazawa University)

[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_46

[M-AG41] Dynamics of radionuclides emitted from Fukuchima Dai-ichi Nuclear Power Plant in the environment

convener:Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Daisuke Tsumune(Central Research Institute of Electric Power Industry)

[MAG41-P01] Discovering U particle with Zr from CsMP emitted from Unit 1 of FDNPP using synchrotron radiation X-ray analyses

*Hikaru Miura[1], Yuichi Kurihara[2], Masayoshi Yamamoto[3], Aya Sakaguchi[4], Kazuya Tanaka[2], Shogo Higaki[5], Yoshio Takahashi[5] (1.Central Research Institute of Electric Power Industry, 2.JAEA, 3.University of Kanazawa, 4.University of Tsukuba, 5.The University of Tokyo)

[MAG41-P02] Atmospheric re-emission of radio-cesium with bioaerosols and trial for estimateing their emission flux

★Invited Papers

*Kazuyuki Kita[1], Naho Hayashi[1], Koutaro Minami[1], Mao Kimura[1], Yasuhito Igarashi[1,7], Kouji Adachi[2], Teruya Maki[3], Atsuyuki Sorimachi[4], Ishizuka Masahide[5], Jun Furukawa[6], Kazuhiko Ninomiya[8], Atsushi Shinohara[8], Olivier Masson[9] (1.Graduate School of Science and Engineering, Ibaraki University, 2.Meteorological Research Laboratory, 3.Kanazakwa University, 4.Fukushima Medical Univeristy, 5.Kagawa University, 6.Tsukuba University, 7.Kyoto University, 8.Osaka University, 9.IRSN)

[MAG41-P03] The effect of canopy interception processes on radiocesium and dissolved matter concentrations in throughfall

*Tomoki Shinozuka[1], Hiroaki Kato[2], Satoru Akaiwa[1], Yuichi Onda[2] (1.College of Geoscience, School of Life and Environmental Sciences, University of Tsukuba, 2.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba)

[MAG41-P04] Effects of RCs concentration and dissolved organic matter on RCs migration in soil under flowing condition

*Takahiro Tatsuno[1], Shoichiro Hamamoto[1], Naoto Nihei[1], Taku Nishimura[1] (1.Deptartment of Biological and Environmental Engineering, Graduate School of Agricultural and Life Sciences, University of Tokyo)

[MAG41-P05] Behavior of dissolved radiocesium in the decay degree of organic matter of deciduous broad-leaved trees

*Yoshito Sasaki[1], Tadafumi Niizato[1], Katsuaki Mitachi[2], Satomi Ito[1], Takayoshi Watanabe[1] (1.Japan Atomic Energy Agency , 2.ATOM TRANSPORT SERVICE CO., LTD)

[MAG41-P06] Effect of Coarse Organic Matter on the Dissolved Radioactive Cesium Concentration in Stream Water from headwater catchment

*Satoru Akaiwa[1], Hiroaki Kato[2], Tomoki Shinozuka[1], Yuichi Onda[2] (1.College of Geoscience, School of Life and Environmental Sciences, University of Tsukuba, 2.Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba)

[MAG41-P07] Eight-year monitoring study of radiocesium transfer in forest environments after the FDNPP accident

*Hiroaki Kato[1], Yuichi Onda[1], Zul Hilmi Saidin[1], Momo Kurihara[1], Tomoki Shinozuka[2], Satoru Akaiwa[2] (1.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, 2.College of Geoscience, School of Life and Environmental Sciences, University of Tsukuba)

[MAG41-P08] Seasonal change of radiocaesium and its factor in the forest catchment contaminated by the Fukushima Dai-ichi Nuclear Power Station Accident

★Invited Papers

*Shota Kambayashi[1], Tatsuo Aono[1], Hiroki Hamajima[1], Hiroyuki Takahashi[1], Mitsuru Yamamura[2], Yutaka Yamada[1] (1.National Institute of Radiological Sciences, National Institutes for Quantum and Radiological Science and Technology, 2.Japan Conservation Engineers & Co.,LTD Inc.)

[MAG41-P09] Research of discharge radioactive Cs-bearing microparticles from a small forested catchment

*Satoshi Hadano[1], Shoichiro Hamamoto[1], Naoto Nihei[1], Taiga Okumura[1], Toshihiro Kogure[1], Taku Nishimura[1] (1.The University of Tokyo)

[MAG41-P10] Estimating impacts of direct release and riverine discharge on oceanic ^{137}Cs derived from the Fukushima Dai-ichi Nuclear Power Plant accident by an regional ocean model

★Invited Papers

*Daisuke Tsumune[1], Tsubono Takaki[1], Kazuhiro Misumi[1], Yutaka Tateda[1], Yuichi Onda[2], Michio Aoyama[3] (1.Central Research Institute of Electric Power Industry, 2.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, 3.Institute of Environmental Radioactivity, Fukushima University)

[MAG41-P11] FNPP1 accident derived radiocaesium and tritium in Fukushima coast through the end of 2018

*Michio Aoyama[1], Yasunori Hamajima[2], Yayoi Inomata[2], Yuichiro Kumamoto[3], Tsubono Takaki[4], Daisuke Tsumune[4] (1.Institute of Environmnetal Radioactivity, Fukushima University, 2.Institute of Nature and Environmental Technology, Kanazawa university, 3.Japan Agency for Marine-Earth Science and Technology, 4.Environmental Science Research Laboratory, Central Research Institute of Electric Power Industry)

[MAG41-P12] Radiocesium in the swash zones off the coast of the Japan Sea

*Hyoe Takata[1], Mutsuo Inoue[2], Natsumi Kudo[1], Yuhei Shirotani[1] (1.Marine Ecoloy Research Institute, 2.Kanazawa Univ.)

[MAG41-P13] Numerical simulation of Cs-137 activity in the North Pacific using two atmospheric deposition fluxes estimated by atmospheric chemical transport models

*Tsubono Takaki[1], Kazuhiro Misumi[1], Daisuke Tsumune[1], Michio Aoyama[2], Katsumi Hirose[3] (1.Central Research Institute of Electric Power Industry, 2.Fukushima University, 3.Sophia University)

[MAG41-P14] Seasonal deposition of radiocesium in wooden houses from summer to winter seven years after the Fukushima nuclear accident

*Ryo Takakura[1], Katsumi Shozugawa[1], Mayumi Hori[1], Motoyuki Matsuo[1] (1.Graduate school of arts and sciences, the university of Tokyo)

[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-SD Space Development & Earth Observation from Space

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_8

[M-SD42] A new era of international space collaboration using microsatellites

convener:Junichi Kurihara(Graduate School of Science, Hokkaido University), Joel Joseph Jr Marciano(Advanced Science and Technology Institute, Department of Science and Technology, Philippines), Huy Xuan Le(Vietnam National Space Center)

[MSD42-P01] A high spatial resolution multispectral remote sensing by the RISESAT microsatellite

*Junichi Kurihara[1], Toshinori Kuwahara[2], Shinya Fujita[2], Yuji Sakamoto[2], Yukihiro Takahashi[1] (1.Graduate School of Science, Hokkaido University, 2.Graduate School of Engineering)

[MSD42-P02] Initial check out and experiment plan of Very Small Optical Transmitter (VSOTA) on board a micro satellite RISESAT for Space-Ground Optical Communication

*Hiroo Kunimori[1], Hideki Takenaka[1], Toshinori Kuwahara[2], Yuji Sakamoto[2], Shinya Fujita[2], Hannah Tomio[2], MOROKOT SAKAL[2], Junichi Kurihara[3] (1.National Institute of Information and Communications Technology, 2.Tohoku Univ., 3.Hokkaido Univ.)

[MSD42-P03] Ten years history of Tohoku University ground station and operation system for micro and nano satellites

*Yuji Sakamoto[1], Toshinori Kuwahara[1], Shinya Fujita[1] (1.Tohoku University)

[MSD42-P04] Development of Thermal Infrared Sensor Camera on board LAPAN-A4 for Thunderstorm Cloud Observation

*Purwadi Purwadi[1,2], Yukihiro Takahashi[1], Junichi Kurihara[1], M. Arif Saifudin[3] (1.Department of Cosmosciences, Hokkaido University, Sapporo 0600810, Japan, 2.Agency for Assessment and Application of Technology (BPPT), Jakarta 10340, Indonesia, 3.Indonesian National Institute of Aeronautics and Space (LAPAN), Jawa Barat, 16310, Indonesia)

[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-SD Space Development & Earth Observation from Space

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_47

[M-SD42] A new era of international space collaboration using microsatellites

convener:Junichi Kurihara(Graduate School of Science, Hokkaido University), Joel Joseph Jr Marciano(Advanced Science and Technology Institute, Department of Science and Technology, Philippines), Huy Xuan Le(Vietnam National Space Center)

[MSD42-P01] A high spatial resolution multispectral remote sensing by the RISESAT microsatellite

*Junichi Kurihara[1], Toshinori Kuwahara[2], Shinya Fujita[2], Yuji Sakamoto[2], Yukihiro Takahashi[1] (1.Graduate School of Science, Hokkaido University, 2.Graduate School of Engineering)

[MSD42-P02] Initial check out and experiment plan of Very Small Optical Transmitter (VSOTA) on board a micro satellite RISESAT for Space-Ground Optical Communication

*Hiroo Kunimori[1], Hideki Takenaka[1], Toshinori Kuwahara[2], Yuji Sakamoto[2], Shinya Fujita[2], Hannah Tomio[2], MOROKOT SAKAL[2], Junichi Kurihara[3] (1.National Institute of Information and Communications Technology, 2.Tohoku Univ., 3.Hokkaido Univ.)

[MSD42-P03] Ten years history of Tohoku University ground station and operation system for micro and nano satellites

*Yuji Sakamoto[1], Toshinori Kuwahara[1], Shinya Fujita[1] (1.Tohoku University)

[MSD42-P04] Development of Thermal Infrared Sensor Camera on board LAPAN-A4 for Thunderstorm Cloud Observation

*Purwadi Purwadi[1,2], Yukihiro Takahashi[1], Junichi Kurihara[1], M. Arif Saifudin[3] (1.Department of Cosmosciences, Hokkaido University, Sapporo 0600810, Japan, 2.Agency for Assessment and Application of Technology (BPPT), Jakarta 10340, Indonesia, 3.Indonesian National Institute of Aeronautics and Space (LAPAN), Jawa Barat, 16310, Indonesia)

[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-SD Space Development & Earth Observation from Space

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[M-SD42] A new era of international space collaboration using microsatellites

convener:Junichi Kurihara(Graduate School of Science, Hokkaido University), Joel Joseph Jr Marciano(Advanced Science and Technology Institute, Department of Science and Technology, Philippines), Huy Xuan Le(Vietnam National Space Center), Chairperson:Junichi Kurihara(Hokkaido University), Tetsuro Ishida(Hokkaido University)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MSD42-01] Present status of Asian Micro-satellite Consortium

*Yukihiro Takahashi[1] (1.Department of Cosmosciences, Graduate School of Science, Hokkaido University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MSD42-02] **Updates on the Development of the Image Acquisition and Scheduler Portal for the Asian Microsatellite Consortium (AMC) from the Philippines' STAMINA4Space Program**

*Mark Edwin Tupas[1], Alvin Retamar[2], Gay Jane Perez[1], Joel Joseph Jr Marciano[2], Romer Kristi Aranas[1], Benjamin Joseph Jiao[1] (1.University of the Philippines - Diliman, 2.Department of Science and Technology - Advanced Science and Technology Institute)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MSD42-03] **Overview of MicroDragon, a microsatellite for ocean color observation**

*Huy Xuan Le[1], Thao Thi Nguyen[1], Junichi Kurihara[2] (1.Vietnam National Space Center, 2.Graduate School of Science, Hokkaido University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MSD42-04] Updates on Philippines microsatellites DIWATA-1 and DIWATA-2

*Tetsuro Ishida[1], Mark Jayson Felix[2], Ellison Caparas Castro[2], Shielo Baes Namuco[2], Francisco Miguel Felicio[2], Harry Casimir Merida[2], Kaye Kristine Vergel[2], Gay Jane Perez[2], Joel Joseph Marciano[3,4], Yukihiro Takahashi[1] (1.Faculty of Science, Hokkaido University, 2.Institute of Environmental Science and Meteorology, University of the Philippines Diliman, 3.Advanced Science and Technology Institute, Department of Science and Technology, 4.Electrical and Electronics Engineering Institute, University of the Philippines Diliman)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MSD42-05] MICROSATELLITE TECHNOLOGY DEVELOPMENT STATUS IN MONGOLIA BASED ON ITS NEEDS

*Erdenebaatar Dashdondog[1], Begzsuren Tumendemberel[2], Turtogtokh Tumenjargal[3], Ulam-Orgikh Duger[4] (1.Senior Lecturer of the National University of Mongolia, 2.Hokkaido University, 3.Researcher National University of Mongolia, 4.Professor National University of Mongolia)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MSD42-06] Potential Agricultural Applications of Microsatellites for Malaysian Agriculture

*Abdul Rashid Bin Mohamed Shariff [1], Ahmad Shaqeer Mohamed Thaheer[2] (1.Universiti Putra Malaysia , 2.Hokkaido University)

[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

10:45 AM - 12:15 PM JST | 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_11

[M-TT48] Frontiers in Geochemistry

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Tetsuya Yokoyama(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Hajime Obata(Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo)

[MTT48-P01] Noble gas isotope analysis using a multi-turn time-of-flight mass spectrometer

*Hirochika Sumino[1], Yoshihide Akiyama[1] (1.Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo)

[MTT48-P02] Determination of picomolar of zirconium, hafnium, niobium and tantalum in seawater using chelating resin and subsequent ICP-MS determination

*Hajime Obata[1], Lutfi M. Firdaus[2], Asami S. Mashio[3], Taejin Kim[4], Jason McAlister[5], Toshitaka Gamo[1] (1.Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo, 2.Graduate School of Science Education, University of Bengkulu, Bengkulu, Indonesia, 3.College of Science and Engineering, Kanazawa University, Kanazawa, Japan, 4.School of Earth and Environmental Sciences, Seoul National University, Korea, 5.Department of Earth, Ocean, and Atmospheric Sciences, University of British Columbia, Canada)

[MTT48-P03] Development of ^{3}H-^{3}He groundwater dating method

*Nomata Naoki[1], Hirochika Sumino[1] (1.Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo)

[MTT48-P04] In-situ and meteoric 10Be and 26Al measurements: Improved preparation and application at the University of Tokyo

*Yusuke Yokoyama[1,2,3], Masako Yamane[7], Atsunori Nakamura[4], Yosuke Miyairi[1], Kazuho Horiuchi[5], Takahiro AZE[1], Hiroyuki Matsuzaki[6], Yoshiki Shirahama[4], Yuka Ando[1] (1.Atmosphere and Ocean Research Institute, University of Tokyo, 2.Department of Earth and Planetary Science, University of Tokyo, 3.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, 4.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 5.Graduate School of Science and Technology, Hirosaki University, 6.Micro Analysis Laboratory, Tandem Accelerator, University of Tokyo, 7.Division for Chronological Research, Institute for Space–Earth, Environmental Research, Nagoya University)

[MTT48-P05] Development of seawater stable Ba isotope analysis by DS-TIMS technique

*Shigeyuki Wakaki[1], Yuki Tezuka[2], Takashi Miyazaki[3], Keiji Horikawa[2] (1.Kochi Institute for Core Sample Research, JAMSTEC, 2.Univ. of Toyama , 3.Department of Solid Earth Geochemistry, JAMSTEC)

[MTT48-P06] Sequential radiocarbon measurement on peaty sediments to reconstruct high precision age model of mash deposits

*Yosuke Miyairi[1], Reisuke Kondo[2], Akihiro Yokota[3], Kiyoyuki Shigeno[3], Hiroko Fujita[4], Yusuke Yokoyama[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Kogakkan University, 3.Meiji consultant co.,ltd., 4.The Field Science Center for Northern Biosphere, Hokkaido University)

[MTT48-P07] Preliminary analysis of nucleosynthetic Sr isotope anomalies in amoeboid olivine aggregates from the Allende meteorite

*Yuki Masuda[1], Tetsuya Yokoyama[1], Kunihiro Myojo[1], Satoki Okabayashi[1] (1.Tokyo Institute of Technology)

[MTT48-P08] Measurement of diamagnetic susceptibility and magnetic separation and material identification of organic matter using small permanent magnet

*Keiji Hisayoshi[1], Hiroki Fukuyama[2], Chiaki Uyeda[2], Kentaro Terada[2] (1.Dept. of Earth and Space Science, School of Science, Osaka University, Otemae High School of Osaka prefecture, 2.Dept. of Earth and Space Science School of Science, Osaka University)

[MTT48-P09] Geochemistory and chronology of five howardites, Y-7308, Y-003125, Y-000428, NWA 1929, and NWA 6920

*Motoi Okada[1], Makiko K. Haba[1], Keisuke Nagao[2], Tetsuya Yokoyama[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2.Korea Polar research Institute)

[MTT48-P10] Non-destructive elemental analysis of a carbonaceous chondrite with direct current Muon beam at MuSIC

*Murota Yuta[1], Kentaro Terada[1] (1.Department of Earth and Space Science, Graduate School of Science, Osaka University)

[MTT48-P11] **Nucleosynthetic Sr and Nd isotopic anomalies of bulk differentiated meteorites**

*Ryota Fukai[1], Kei Sugimoto[1], Tetsuya Yokoyama[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

5:15 PM - 6:30 PM JST | 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_48

[M-TT48] Frontiers in Geochemistry

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Tetsuya Yokoyama(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Hajime Obata(Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo)

[MTT48-P01] Noble gas isotope analysis using a multi-turn time-of-flight mass spectrometer

*Hirochika Sumino[1], Yoshihide Akiyama[1] (1.Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo)

[MTT48-P02] Determination of picomolar of zirconium, hafnium, niobium and tantalum in seawater using chelating resin and subsequent ICP-MS determination

*Hajime Obata[1], Lutfi M. Firdaus[2], Asami S. Mashio[3], Taejin Kim[4], Jason McAlister[5], Toshitaka Gamo[1] (1.Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo, 2.Graduate School of Science Education, University of Bengkulu, Bengkulu, Indonesia, 3.College of Science and Engineering, Kanazawa University, Kanazawa, Japan, 4.School of Earth and Environmental Sciences, Seoul National University, Korea, 5.Department of Earth, Ocean, and Atmospheric Sciences, University of British Columbia, Canada)

[MTT48-P03] Development of ^{3}H-^{3}He groundwater dating method

*Nomata Naoki[1], Hirochika Sumino[1] (1.Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo)

[MTT48-P04] In-situ and meteoric 10Be and 26Al measurements: Improved preparation and application at the University of Tokyo

*Yusuke Yokoyama[1,2,3], Masako Yamane[7], Atsunori Nakamura[4], Yosuke Miyairi[1], Kazuho Horiuchi[5], Takahiro AZE[1], Hiroyuki Matsuzaki[6], Yoshiki Shirahama[4], Yuka Ando[1] (1.Atmosphere and Ocean Research Institute, University of Tokyo, 2.Department of Earth and Planetary Science, University of Tokyo, 3.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, 4.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 5.Graduate School of Science and Technology, Hirosaki University, 6.Micro Analysis Laboratory, Tandem Accelerator, University of Tokyo, 7.Division for Chronological Research, Institute for Space–Earth, Environmental Research, Nagoya University)

[MTT48-P05] Development of seawater stable Ba isotope analysis by DS-TIMS technique

*Shigeyuki Wakaki[1], Yuki Tezuka[2], Takashi Miyazaki[3], Keiji Horikawa[2] (1.Kochi Institute for Core Sample Research, JAMSTEC, 2.Univ. of Toyama , 3.Department of Solid Earth Geochemistry, JAMSTEC)

[MTT48-P06] Sequential radiocarbon measurement on peaty sediments to reconstruct high precision age model of mash deposits

*Yosuke Miyairi[1], Reisuke Kondo[2], Akihiro Yokota[3], Kiyoyuki Shigeno[3], Hiroko Fujita[4], Yusuke Yokoyama[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Kogakkan University, 3.Meiji consultant co.,ltd., 4.The Field Science Center for Northern Biosphere, Hokkaido University)

[MTT48-P07] Preliminary analysis of nucleosynthetic Sr isotope anomalies in amoeboid olivine aggregates from the Allende meteorite

*Yuki Masuda[1], Tetsuya Yokoyama[1], Kunihiro Myojo[1], Satoki Okabayashi[1] (1.Tokyo Institute of Technology)

[MTT48-P08] Measurement of diamagnetic susceptibility and magnetic separation and material identification of organic matter using small permanent magnet

*Keiji Hisayoshi[1], Hiroki Fukuyama[2], Chiaki Uyeda[2], Kentaro Terada[2] (1.Dept. of Earth and Space Science, School of Science, Osaka University, Otemae High School of Osaka prefecture, 2.Dept. of Earth and Space Science School of Science, Osaka University)

[MTT48-P09] Geochemistory and chronology of five howardites, Y-7308, Y-003125, Y-000428, NWA 1929, and NWA 6920

*Motoi Okada[1], Makiko K. Haba[1], Keisuke Nagao[2], Tetsuya Yokoyama[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2.Korea Polar research Institute)

[MTT48-P10] Non-destructive elemental analysis of a carbonaceous chondrite with direct current Muon beam at MuSIC

*Murota Yuta[1], Kentaro Terada[1] (1.Department of Earth and Space Science, Graduate School of Science, Osaka University)

[MTT48-P11] **Nucleosynthetic Sr and Nd isotopic anomalies of bulk differentiated meteorites**

*Ryota Fukai[1], Kei Sugimoto[1], Tetsuya Yokoyama[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-TT Technology & Techniques

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC | 201A 2F

[M-TT48] Frontiers in Geochemistry

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Tetsuya Yokoyama(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Hajime Obata(Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo), Chairperson:Hirochika Sumino, Hajime Obata(Atmosphere and Ocean Research Institute, University of Tokyo), Tetsuya Yokoyama(Tokyo Institute of Technology)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MTT48-01] Data science approaches to geochemical data analysis

★Invited Papers

*Kenta Ueki[1] (1.Japan Agency for Marine-Earth Science and Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MTT48-02] Rapid *in situ* analyses of hydrogen and sulfur isotope ratios in basaltic glass by SIMS and their appilications

*Kenji Shimizu[1], Takayuki Ushikubo[1], Tomokazu Murai[2], Fumihiro Matsuura[2], Yuichiro Ueno[2] (1.Kochi Core Center, Japan Agency for Marine-Earth Science and Technology, 2.Tokyo Institute of Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MTT48-03] Determination of siderophile elements in metallic materials using multiple spot laser ablation-ICP-MS technique

*Yoshiki Makino[1], Yasuo Kuroki[2], Takafumi Hirata[1] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.Thermo Fisher Scientific)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MTT48-04] Iron isotopic compositions of Luna 16, 20, 24 soils

★Invited Papers

*Satoki Okabayashi[1], Tetsuya Yokoyama[1], Takafumi Hirata[2], Kazuo Terakado[3], Erick M. Galimov[4] (1.Tokyo Institute of Technology, 2.The University of Tokyo, 3.Japan Space Forum, 4.Russian Academy of Science)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MTT48-05] Synthesis of calcite reference materials for *in situ* U–Pb dating through crystallization from amorphous calcium carbonates

*Yusuke Miyajima[1], Ayaka Saito[1], Hiroyuki Kagi[1], Tatsunori Yokoyama[2], Takafumi Hirata[1] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.Tono Geoscience Center, Japan Atomic Energy Agency (JAEA))

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MTT48-06] Magnetic mapping of a speleothem from the southern Pacific with a scanning SQUID microscopy and its magnetic mineralogy

*Naoto Fukuyo[1,2], Hirokuni Oda[3], Yusuke Yokoyama[1,2], Geoffrey Clark[4], Yuhji Yamamoto[5] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Department of Earth and Planetary Science, The University of Tokyo, 3.Institute of Geology and Geoinformation, 4.College of Asia and the Pacific,The Australian National University, 5.Center for Advanced Marine Core Research, Kochi University)

[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-TT Technology & Techniques

3:30 PM - 5:00 PM JST | 6:30 AM - 8:00 AM UTC | 201A 2F

[M-TT48] Frontiers in Geochemistry

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Tetsuya Yokoyama(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Hajime Obata(Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo), Chairperson:Hirochika Sumino, Hajime Obata(Atmosphere and Ocean Research Institute, University of Tokyo), Tetsuya Yokoyama(Tokyo Institute of Technology)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MTT48-07] Uptake and accumulation of methylmercury by marine phytoplankton

★Invited Papers

*Yuya Tada[1], Kohji Marumoto[1] (1. National Institute For Minamata Disease)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MTT48-08] A protocol for simultaneous analysis of archaeal core and intact polar lipids using normal-phase HPLC/ESI-MS

*Shunsuke Horai[1], Hiroshi Naraoka[1,2] (1.Kyushu University, 2.Research Center for Planetary Trace Organic Compounds)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MTT48-09] Assessment of Northeastern Japan Tree-Ring Oxygen Isotopes for Reconstructing Early Summer Hydroclimate and Spring Arctic Oscillation

*Wataru Sakashita[1,2,3], Yusuke Yokoyama[3], Hiroko Miyahara[2], Takahiro AZE[3], Stephen Obrochta[4], Motonari Ohyama[5], Hitoshi Yonenobu[6] (1.Forestry and Forest Products Research Institute, 2.Musashino Art University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Akita Univeristy, 5.Tohoku University, 6.Naruto University of Education)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MTT48-10] **Development of the rotational diamond anvil cell for high-pressure deformation experiments and its measurement systems**

★Invited Papers

*Shintaro Azuma[1,2], Ryuichi Nomura[3,4], Kentaro Uesugi[5], Yu Nishihara[4], Doi Shunta[4], Takeshi Arimoto[4], Tetsuo Irifune[4] (1.Tokyo Tech., 2.Kyushu Univ., 3.Kyoto Univ., 4.Ehime Univ., 5.JASRI)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MTT48-11] Speciation of metal ions in hydrosphere: Further classification of intermediately hard ligands in HSAB theory

*Makoto Nagasawa[1], Masato Tanaka[1], Asami Miyaji[2], Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Hiroshima University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MTT48-12] Difference in the partition behaviors and speciation between scandium and other rare earth elements in nickel laterite ore deposits

Haibo Qin[1], Kenzo Sanematsu[2], Arcilla Carlo[3], *Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Institute for Geo-Resources and Environment, National Institute of Advanced Industrial Science and Technology (AIST), 3.National Institute of Geological Sciences, College of Science, University of the Philippines)

[E] Oral | U (Union)：Union

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 101 1F

[U-01] JpGU-AGU-EGU Great Debate: Impact of research assessment and going forward

convener:Kazuaki Hori(Department of Geography, Graduate School of Environmental Studies, Nagoya University), Denis-Didier Rousseau(CNRS - ENS), Jonathan L Bamber(member), Chairperson:Yasuhiro Murayama(NICT)

Research assessment mainly based on indices that can be easily quantified such as the number of papers and citations, impact factor, research grant, is spreading among researchers and institutions. However, as typified by DORA (The Declaration on Research Assessment), there has been a movement to review and improve this situation. In this great debate, we discuss the impact of research assessment on researchers, research institutes, research funding agencies, publishers, and even society, based on the current problems of research assessment.

1:45 PM - 3:15 PM JST | 4:45 AM - 6:15 AM UTC

[U01-01] Panel discussion about research assessment

*Kazuaki Hori[1] (1.Department of Geography, Graduate School of Environmental Studies, Nagoya University)

Panel discussion about research assessment

*Kazuaki Hori[1]

1. Department of Geography, Graduate School of Environmental Studies, Nagoya University

Research assessment mainly based on indices that can be easily quantified such as the number of papers and citations, impact factor, research grant, is spreading among researchers and institutions.

However, as typified by DORA (The Declaration on Research Assessment), there has been a movement to review and improve this situation.

In this JpGU-AGU-EGU great debate, we discuss the impact of research assessment on researchers, research institutes, research funding agencies, publishers, and even society, based on the current problems of research assessment.

We will invite experts on the issues. Please join discussions and exhange opinions concerning research assessment.

Keywords: research assessment, scientific research, open science

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[E] Oral | U (Union)：Union

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 101 1F

[U-02] Advancing workplace: progress, challenges and strategies for improvement

convener:Chiaki T. Oguchi(Institute for Environmental Science and Technology, Graduate School of Science and Engineering, Saitama University), Rie Hori, S.(Department of Earth Science, Faculty of Science, Ehime University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Claudia Jesus-Rydin(European Research Council), Chairperson:Rie Hori, Chiaki Oguchi

We are inviting contributions form participants who is interested or has had personal experience in dealing with diversity issues, such as first-hand reports from role models (researchers at different stages of their carriers), as well as perspective views from leaders of research or educational institutions. We welcome submissions from researchers and students working in Japan, both Japanese and foreign, as well as from JpGU2019 participants from other countries. Contributions to this session will be synthesized to highlight the current state of workplace diversity in Japan, and to develop successful strategies and practices for improvement and maintaining diversity in Geosciences. This session is co-sponsored by the Union Symposium US 4 of EGU 2019 "Promoting and supporting equality of opportunities in geosciences" in order to share and exchange current status information with the EGU / AGU community.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[U02-01] Managing Diversity and Inclusiveness

*Jessica Federman[1] (1.California State University, Dominguez Hills)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[U02-02] Adina Paytan 12:36 PM (0 minutes ago)
to me **Where Have All the Women Gone?**

★Invited Papers

*Adina Paytan[1] (1.University of California Santa Cruz)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[U02-03] Gender balance and diversity in the ocean and geosciences: IODP, research cruise, and laboratories

*Natsue Abe[1] (1.R&D Center for Ocean Drilling Science Japan Agency for Marine-Earth Science and Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[U02-04] Problem in paternity leave

*Yukihiro Takahashi[1] (1.Department of Cosmosciences, Graduate School of Science, Hokkaido University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[U02-05] Challenges in teaching interactive lectures with high student diversity using student response systems

★Invited Papers

*Thomas Parkner[1], Verena Pietzner[2] (1.University of Tsukuba, 2.University of Oldenburg)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[U02-06] **The AGU Ethics and Equity Center: New Resources for Advancing Workplace Excellence**

Brooks Hanson[1], Christine McEntee[1], Robin Elizabeth Bell[1], *Billy M Williams[1] (1.American Geophysical Union)

Managing Diversity and Inclusiveness

*Jessica Federman[1]

1. California State University, Dominguez Hills

There is considerable interest in understanding the ways in which diversity can improve work processes and organizational outcomes (Gonzalez & DeNisi, 2009; Homan, Hollenbeck, Humphrey, van Knippenberg, Ilgen, & Van Kleef, 2008) as well as identifying how to attract, retain, and integrate diverse populations in various fields of science (Thomas & Ely, 1996). A promising area of research that's resolved to meet this objective is focused on creating work environments where diverse individuals feel included (Bilimoria, Joy, & Liang, 2008; Roberson, 2006), otherwise known as inclusiveness. The current paper discusses several studies and bodies of work that provide a collection of tools to retain and promote the notion of inclusiveness for underrepresented minorities in geoscience fields and in general, promote diversity in the workplace. The paper focuses on theory and empirical work on inclusiveness, diversity and discrimination in employment and highlights contextual and conceptual tools that address the needs of various fields (including cultural and geographically different environments) and the evolvement and progress of this literature moving forward.

Keywords: Mentoring , Diversity, Inclusiveness

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Adina Paytan <apaytan@ucsc.edu> 12:36 PM (0 minutes ago) to me **Where Have All the Women Gone?**

*Adina Paytan[1]

1. University of California Santa Cruz

The representation of women in STEM (*Science, Technology, Engineering and Mathematics*) matters. Diversity in the workforce contributes to creativity, productivity, innovation, and success. The STEM fields in general and Earth Sciences in particular have long been plagued by the under-representation of women. Men tend to dominate in the field, and the numbers of women simply aren't growing the way one would hope. Although women iin most countries earn just over 40% of the bachelor's degrees in the field, they accounted on avarage for just 20% of faculty in 2015, with considerablle differences between countries. The troubling disparity has been attributed to a number of factors; including deeply embedded culture based psychological barriers and failures by elementary and high schools to spark girls' interests in math and science. In colleges, the reasons for high attrition rates of women from STEM majors often cite insufficient support, and a lack of female role models. At the department, college, or institutional level emerging research suggest that a "chilly climate" environment where gender stereotypes, bias and inequality prevail. Lack of mentoring and supportive policies (particularly for work–life balance) also contribute to the "leaky pipeline" a metaphor for the greater likelihood for women to leave STEM fields at every point, from recruitment to attrition after graduation; because of a significant amount of barriers. Institutional changes in policy and structure including increasing awareness and training to reducing bias, along with strategies like implementing mentoring programs and fostering social accountability, are some of the possible solutions. While some progress has been made and we are on the right track there is still a distance to the mark line and mountains to climb along the way.

Keywords: Women in Science, Leaky pipeline, Role Models

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Gender balance and diversity in the ocean and geosciences: IODP, research cruise, and laboratories

*Natsue Abe[1]

1. R&D Center for Ocean Drilling Science Japan Agency for Marine-Earth Science and Technology

Approximately 600 people from all over the world participated in the workshop in order to prepare scientific targets for the next decade of the Integrated Ocean Drilling Program (IODP) [1] held in Bremen in 2009 [2], of which about 30% were women. Meanwhile, among the 100 participants from Japan, there were only 6 women (6% !!). Why is there a big gap between Japan and other countries? Did this gap shrink over the past 10 years?

My research field is mainly in ocean science now. Female researchers were 17 –33 % of the science parties among my 8 times participations on drilling expeditions. However, even in the United States, people have been straggling to increase female researchers in this field [3]. Our outreach activities always include some contents targeting to female students [4]. Women for one ocean [4] has established among Japanese scientists, and start working and supporting for female workers in the ocean science.

I will talk about the international projects especially in the ocean sciences that I experienced through my career and diversity situation in overseas' research laboratory. Then I would like to have a discussion on why gender balance and diversity are difficult to progress in Japan.

References

[1] IODP: http://www.iodp.org/

[2] IODP INVEST workshop: https://www.marum.de/en/Research/INVEST.html

[3] Women in Oceanography: A Decade later. (E.S. Kappel, Ed). Oceanography, vol. 27, 2015. https://doi.org/10.5670/oceanog.2014.106

[4] https://joidesresolution.org/women-in-geoscience-and-technics-heather/

[5] Women in One Ocean: https://oceanwomenjp.wixsite.com/website

Keywords: gender balance, diversity, IODP

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Problem in paternity leave

*Yukihiro Takahashi[1]

1. Department of Cosmosciences, Graduate School of Science, Hokkaido University

I took childcare leave in 1999 and 2004 for half year and three months, respectively. At that time only 75 ppm of men took this leave for more than 3 months. Still only about 5 percent men take it (including very short one) now. There is a list of reasons why they didn’ t take it on the government web page. However, I think one of the most essential reason that cannot appear on such research is the lack of international common sense related to the gender issues.

Keywords: childcare leave, gender gap

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Challenges in teaching interactive lectures with high student diversity using student response systems

*Thomas Parkner[1], Verena Pietzner[2]

1. University of Tsukuba, 2. University of Oldenburg

Interactive teaching is becoming increasing popular in higher education, as students who engage in the learning process learn more. Student response systems - also called clickers –are an engagement tool, which promotes such interactivity as students increase their engagement in lectures. In a globalizing world, student diversity has become greater in many institutions, while publications on clickers focus on courses with similar student background. In this study, the effect of clickers on the learning climate in lectures with high student diversity is analyzed to differentiate the clicker effect.

A questionnaire was developed containing 29 questions on learning climate categorized in the seven dimensions comprehensibility, opportunity to participate, subject relevance, class participation, willingness to participate, own performance, and satisfaction. In the first session of each lecture, students were asked to describe their ideal geoscience lectures. In the following session set, effects of clickers on learning climate was compared to lectures without clicker usage. Typically three of such sets were evaluated by the students per lecture followed by the final evaluation of the whole lecture. Statistical analyses were performed using the Mann–Whitney U test and Kruskal–Wallis H test.

For each clicker session, the question difficulty was staggered from recall questions, over conceptual understanding questions, over application questions, to critical thinking questions. The clicker sessions were performed at the end of the sessions with question numbers ranging between 7 and 12 questions.

In total 174 students participated in 12 undergraduate geoscience lectures at the University of Tsukuba. In terms of student type, students were classified into degree students in the Integrated Life & Environmental Sciences program in English (with majors in geoscience, biology and agro-biological resource science) from 34 countries with 64.9%, into geoscience in the Japanese program with 14.4%, and into exchange students with 20.7%. 59.4% of the students were female and 40.6% male.

In general, sessions with clicker usage were rated better in all dimensions. Using clicker, students ($n = 806$) feel more satisfied ($U = 71746.5$, $Z = -2.876$, $p = 0.004$), and they ($n = 805$) sense a higher relevance of the topics ($U = 73455.5$, $Z = -2.269$, $p = 0.023$). In addition, they ($n = 786$) think they have more possibilities to actively take part in the lecture ($U = 69468.0$, $Z = -2.446$, $p = 0.014$), and they ($n = 785$) also use this possibility significantly higher than in lectures without clicker ($U = 69432.5$, $Z = -2.403$, $p = 0.016$).

Gender-specific differences for the initial lecture and the usage of clickers became evident. For ideal lectures, student views differed tendentially in three dimensions. For female students ($n=82$), topic relevance is significantly more important ($U = 1717.000$, $Z = -1.903$, $p = 0.057$) than for male students ($n=52$). In addition, the participation of the whole class ($U = 1733.500$, $Z = -1.838$, $p = 0.066$) as well as the own participation ($U = 1763.500$, $Z = -1.697$, $p = 0.090$) is more important for female students. Gender differences were also shown for the usage of clickers. In sessions with clickers, female students ($n=239$) rate the dimensions of comprehension ($U = 14649.500$, $Z = -2.752$, $p = 0.006$) and course participation ($U = 15432.500$, $Z = -2.022$, $p = 0.043$) significantly higher than males ($n =147$). In sessions

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without clicker, no gender-specific differences were found.

Comparing degree students enrolled in the English and Japanese program significant differences were identified. Regarding comprehension (U = 5426.500, Z = -2.415, p = 0.016) and own participation (U = 5761.000, Z = -1.799, p = 0.072), the students in the English program (n =235) rated the lectures with clicker better than the students in the Japanese program (n =58). In contrast, the students in the Japanese program rated the possibility to participate (U = 5403.000, Z = -2.157, p = 0.031) as well as the course participation (U = 5352.500, Z = -2.251, p = 0.024) significantly higher. Exchange students were less satisfied when clickers were used, possibly due to the difficulty to answer questions correctly.

These results on the learning climate in lectures with high student diversity indicate the clickers are not a guarantor for positive effects on learning climate. Aligning question difficulty with student level is a challenging task for lectures with high student diversity.

Keywords: student diversity, student response systems

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The AGU Ethics and Equity Center: New Resources for Advancing Workplace Excellence

Brooks Hanson[1], Christine McEntee[1], Robin Elizabeth Bell[1], *Billy M Williams[1]

1. American Geophysical Union

Issues associated with ethics, equity and diversity in the Earth and space sciences, including the issue of harassment and its impact on women scientists, are now well known and documented. Building on its earlier work of establishing an updated AGU Ethics Policy which defines harassment as scientific misconduct, the American Geophysical Union (AGU) has taken additional significant steps over the past 12 months to further advance ethics and equity practices, including steps to help prevent harassment. This presentation will highlight the unique role that professional societies can take to help change the culture in science, technology engineering and math (STEM) fields, and the AGU actions and results to-date, including the introduction of a new Ethics and Equity Resource Center, and the establishment of a formal coalition of more than fifty scientific societies in the U.S. to help address harassment and associated issues in science. Progress to date and remaining challenges to advance ethics and equity-related practices, and to track the impact of these changes, will be discussed.

Keywords: Ethics, Diversity, Harassment, Inclusion, Work climate, Equity

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | IC 2F

[O-01] Exploring Buratamori - How to make science accessible

convener:Kazutaka Mannen(Hot Springs Research Institute of Kanagawa Prefecture), Takayuki Ogata(Disaster Prevention Research Center for Island Regions, University of the Ryukyus), Chairperson:Takayuki Ogata

Buratamori is a Saturday prime-time TV show of NHK (Japanese public broadcasting). Each episode features geoscience of a region including geography, geology, history and ecology, and local experts host a comedian named Tamori, who has a wide knowledge and a female announcer, who represents ordinary citizen. Such a style of the show has been popular among people in this decade and geoscience experts also highly regard the show. In this session, directors and previous hosts of the show describe its making process from each point of the view. Since the show needs to reach widely, bold simplification of complex scientific context is sometimes unavoidable, and this makes tension between the producers and experts. Through the session, we would like to discuss how the experts can make a simple but adequate explanation for geoscience issues to wide audience.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[O01-01] Lessons from Buratamori – An introduction to the session

★Invited Papers

*Kazutaka Mannen[1] (1.Hot Springs Research Institute of Kanagawa Prefecture)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[O01-02] **The history of Buratamori**

★Invited Papers

*Mikio Hayashi[1] (1.Japan Broadcasting Corporation)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[O01-03] My experience as a geoscientific guide for the NHK-TV program Buratamori

★Invited Papers

*Masato Koyama[1] (1.Shizuoka Univ.)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[O01-04] A Visualized History by Buratamori

★Invited Papers

*Noriko Matsuda[1] (1.Kyoto Prefectural University)

2:45 PM - 3:15 PM JST | 5:45 AM - 6:15 AM UTC

[O01-05] General discussion 1

*Takayuki Ogata[1] (1.Disaster Prevention Research Center for Island Regions, University of the Ryukyus)

Lessons from Buratamori –An introduction to the session

*Kazutaka Mannen[1]

1. Hot Springs Research Institute of Kanagawa Prefecture

Buratamori, airing from 7:30 pm on every Saturday, is a TV program broadcasted by NHK (Japanese public broadcast). In the program, local experts on geology, geography and history host a well-known TV talent Tamori and a female announcer and stroll a location to reveal its history and development with them. This program originally started in 2008 as a late-night program featuring areas in Tokyo and its surrounding and won the Geographical Society of Japan Award in 2011. Since 2015, the TV program has been aired in the prime time as the present and began to feature locations all over Japan. After this time, the TV program has won awards from National Geographical Information Authority of Japan, Geological Society of Japan and Japanese Geotechnical Society. As implied from presenters of the awards, the Buratamori is highly recognized by earth scientists in Japan. In this session, we would like to reveal how the program, which satisfies even professional earth scientists, was made from diversified stand points including the TV producer, experts who host the show and the audience. The followings are my schedule and personal impression when I hosted the show.

I have hosted three episodes entitled “Hakone” (aired on April 22, 2017), “Hakone Sekisho (checkpoint)” (May 13, 2017), and “Hot springs in Hakone” (October 6, 2018), as a local geological expert. The preparation process for the episodes aired in 2017 began in the late December 2016 with a phone call from NHK to my office. The crew spent all January in 2017 to gather diverse information of the featuring area. The outlines of the episodes were fixed in the mid-February and I was requested to be the host by the directors. In the early March, the directors presented scripts for the episodes and a rehearsal without Tamori and the announcer was held. The shooting was held in the mid-March. After the filming, I was requested to review the the scripts of narration and animation movies that would be used in the episodes to help audience to understand until 2 weeks before the airing.

The preparation process of the program, which includes intensive information gathering by the crew members and detailed discussion with the experts, were interesting and very impressive for me. The effort made by crew to keep the cast members relax during filming was also impressive.

Recently, chances for scintist to explain his/her research to the taxpayers are increasing. Such a scientist can learn from the TV crews who have several specific capabilities including 1) extensive information gathering, 2) insight that extracts reality of the featuring area, 3) story making to convey the gathered information to the public and 4) efforts to keep the filming location relax and delightful.

On the other hand, the TV program simplifies scientific context boldly and this bothers experts in the show deeply. In my talk, my experience of such simplification will be also presented and discussed briefly.

Keywords: Buratamori, TV program, outreach

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The history of Buratamori

*Mikio Hayashi[1]

1. Japan Broadcasting Corporation

Development of the program

TV program “Buratamori” (City walking with Tamori’s view) started as a pilot late-night program in December 2008. At that time, NHK (Japan Broadcasting Corporation) had a unit named Program Development. Four members of the unit including the author created the program. The first episode of “Buratamori” was “Harajyuku and Omote-sando”. Even it was aired in the late night, the episode, which deeply read city sceneries looked by many people every day, received a lot of feedbacks from the audience.

Starting as a regular program

After the airing of the pilot version, the program started as a regular series including 15 episodes (October 2009 to Marth 2010) aired from 10:00 pm, each of which was 43 minutes long. Tamori hosted a regular program on NHK for the first time in the 20 years since he had hosted a show named “Watching”. After that, Buratamori had continued as a regular program of a season from October to March for 3 years. During this period, corners named “Delusion CG”, which created imaginal ancient view of a town using computer graphic, and “Buratamo photo studio”, which showed photos taken by Tamori, were popular. In the presentation, the author will show the materials used in the development of the program.

Making of the first Buratamori

The early program looks same as the present style from the audience’s view but there are differences. Most of the experts appeared in the program were researcher of civil engineering especially urban planning, development and renovation. The most significant difference of the making is the walking time by the directors. At that time, “riddle” given to Tamori in the present program does not exist. However, Tamori found “mysterious scenery” in the show and the background of the scenery was explained in the program. Since it was very difficult to find “mysterious scenery” and “topic” in the well-known Tokyo, the directors of the program walked a lot to search them until their shoes literary wearing out.

Present

The present regular broadcast from 19:30 pm every Saturday started from April 2015 has been watched by many people. Buratamori features joy of walking in the city; however, tend to focus on geology a lot recently. The present version continued 5 years. We would like to focus on not only geology but also history, geography, customs and culture depending on episodes to be an attractive TV program that

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unlock the secret of city and history of the location.

Keywords: TAMORI, Buratamori

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My experience as a geoscientific guide for the NHK-TV program Buratamori

*Masato Koyama[1]

1. Shizuoka Univ.

Buratamori is a popular NHK-TV program featuring a famous talent, Mr. Tamori, who visits various localities and tries to solve subjects about origins of local natural and social sceneries, products, and sightseeing resources. Many geoscientists, biologists, archeologists, historians, and other natural and social scientists appear as guides and lead Mr. Tamori to a final answer for each round of the program. The involving scientists do not only play touring guides but also make much efforts as advisors for selection of localities and contents. They also propose experiments showing natural processes and check scenarios, narration, and explanatory CG animations etc. The author reports experience as one of the geoscientific guides for the Buratamori and considers about how to explain complicated scientific knowledge simply, comprehensibly, and enjoyably.

Keywords: Buratamori, guide, geoscientist, TV program, outreach

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A Visualized History by Buratamori

*Noriko Matsuda[1]

1. Kyoto Prefectural University

A lecturer is an urban and architectural historian researching history of development and origin of cities from geological, architectural, social and cultural point of view. Backgrounds and circumstances which have had brought the current situation of lands, our dwelling spaces or any other spaces and places related to our life, have being explored through out the research. Essential relationship between lands and human and its fundamental meanings are considered from these studies.
Buratamori sets a question about a location near around the beginning of the show. The question seems to be an easy question to answer so that television viewers and actors can casually imagine a plot of the show whether if he/she is for or against the question.
However, giving an appropriate answer to this “easy” question is actually not an easy thing even for experts. This is not just because the question was created by a production team referenced various fields of academic studies, but also it was intended to allow anyone who have heard the question would associate the phrase with the location. That is to say, the question is well-balanced between academic complexity and popular understandability.
After giving the question, a route of city/land walk is defined by the question. Several experts will describe the place in turn and turn about during the walk. This relay-style description gives plurality or gives diversified observation. Finding an answer to the question in such way is similar to method of field survey. In a field survey, an object that are huge scale things such as cities, mountains or civil engineered structures or a vast scale of time are physically comprehended through our hands, feet or eyes that are literally small human scaled subject.
Therefore, the route or the plot of the show tends to be something that is visually understandable due to its media, a TV show. For example, historical documents, pictures and photos or remains at the site will fulfill a role. On the other hand, things that are not clear at a glance or articles that are historically important requiring complicated description are omitted. Such topics will be examined in the symposium.

Keywords: Buratamori, outreach, urban history, TV program, guide

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General discussion 1

*Takayuki Ogata[1]

1. Disaster Prevention Research Center for Island Regions, University of the Ryukyus

We will accept questions from the floor and have some discussions based on the questions.

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | IC 2F

[O-01] Exploring Buratamori - How to make science accessible

convener:Kazutaka Mannen(Hot Springs Research Institute of Kanagawa Prefecture), Takayuki Ogata(Disaster Prevention Research Center for Island Regions, University of the Ryukyus), Chairperson:Kazutaka Mannen(Hot Springs Research Institute of Kanagawa Prefecture)

Buratamori is a Saturday prime-time TV show of NHK (Japanese public broadcasting). Each episode features geoscience of a region including geography, geology, history and ecology, and local experts host a comedian named Tamori, who has a wide knowledge and a female announcer, who represents ordinary citizen. Such a style of the show has been popular among people in this decade and geoscience experts also highly regard the show. In this session, directors and previous hosts of the show describe its making process from each point of the view. Since the show needs to reach widely, bold simplification of complex scientific context is sometimes unavoidable, and this makes tension between the producers and experts. Through the session, we would like to discuss how the experts can make a simple but adequate explanation for geoscience issues to wide audience.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[O01-06] The role of experiment in NHK's entertainment / educational program "Buratamori"

★Invited Papers

*Shintaro Hayashi[1] (1.Akita University Graduate School of Education)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[O01-07] An attempt of field work for middle and high school students to comprehend an “area” in an integrated manner

★Invited Papers

*Takeshi Uemura[1], Shigeyuki Yokoi[2] (1.Osaka Prefectural Otemae Senior High School part-time course, 2.Kaijo Junior and Senior High School)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[O01-08] Desirable way of outreach activities in the Museum,learn by participating in the making process of "Buratamori".

★Invited Papers

*Inoue Motoko[1] (1.Saitama Museum of Natural History)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[O01-09] Methodology of Geoscientific Outreach of “Buratamori”

★Invited Papers

*Takayuki Ogata[1] (1.Disaster Prevention Research Center for Island Regions, University of the Ryukyus)

4:30 PM - 5:00 PM JST | 7:30 AM - 8:00 AM UTC

[O01-10] General discussion 2

*Kazutaka Mannen[1] (1.Hot Springs Research Institute of Kanagawa Prefecture)

The role of experiment in NHK's entertainment / educational program "Buratamori"

*Shintaro Hayashi[1]

1. Akita University Graduate School of Education

What is "Buratamori"?

"Buratamori" is an entertainment / educational program that has been broadcast from NHK(Nippon Hoso Kyokai;Japan Broadcasting Corporation) TV since 2008, and its viewer rating sometimes exceeds 15%. In the program, both Tamori and NHK 's beautiful female announcer are thinking about various questions while walking around various places and discovering various things. Also, the program progresses according to the question of the guiding person. Something related to geology and geography often appears in the question, and it exerts a great effect on outreach of earth science. I appeared as the main guide person of "# 81 Towada Lake and Oirase: Why did Towada Lake become a mysterious lake?".

Guide person's responsibility

The Guide person of "Buratamori" is responsible for the scientific accuracy of the program.In order to guarantee the accuracy of the program, the guidance person takes a lot of time to investigate. In the case of a speaker, I referred to more than 100 books and papers related to Towada Lake and Oirase gorge. In addition to this, the guiding person also attends work of the location and rehearsals, to ensure the accuracy of the program.

Experiment in "Buratamori"

In the program of "Buratamori", experiments are often used as a means of explanation. In the program of "# 81 Towada Lake and Oirase: Why did Towada Lake become a mysterious lake?", I explained how to make Lake Caldera using cocoa and condensed milk.

Requirements for experiment to be adopted in "Buratamori"?

Actually, there are many experiments which were not adopted in the program. One example is "water cooled fractured lava experiment". I suggested it twice in other programs of "Buratamori", but both were rejected.Probably the reason for rejecting "water-cooled fractured lava experiment" is 1) it is not visual, 2) the materials such as glass and water are not very impressive.

"Buratamori" and outreach

Outreach activities in the field of earth science are important in three points: 1) acquisition of research funding; 2: training of successors; 3: recognition by the general public (Kamada, 2004). For that reason, it is necessary for scientists to transmit the results obtained by earth science in an easy-to-understand manner.

There are two outreaching effects of "Buratamori" . Firstly, "Buratamori" has a high viewer rating and outreach to many citizens is possible. Secondly, educational effect on scientists is great. Scientists learn how to make the program easier from the director.

Becoming a guide person of "Buratamori" is to use a lot of energy and time. However, as there is a large outreach effect, researchers should respond positively.

Keywords: "Buratamori", experiment, outreach

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An attempt of field work for middle and high school students to comprehend an “area” in an integrated manner

*Takeshi Uemura[1], Shigeyuki Yokoi[2]

1. Osaka Prefectural Otemae Senior High School part-time course, 2. Kaijo Junior and Senior High School

In the school education, things in our daily life and society are subdivided into subjects to study. Specialized teachers teach in the classes of middle and high schools and students tend to attend a class passively. However, the real things are mixture of contents dealt in various subjects. To solve emerging problems in our society, we need an ability to cooperate perseveringly with people having various background.

Based on this perspective, the authors launched a course named “General Field Exercise” for students between third-year of middle school and second year of high school. Approximately 15 students voluntarily attended the course, which lasted for two years. In this course, we focused on an “area” as the study target. Participants who have various background explore the “area” to comprehend the “area” in an integrated manner. Teachers of various subjects including earth science, Japanese history, Japanese language and etc. in charge of the course tried to study with the students from their point of view. Before going out to the “area”, teachers and students had a discussion in the classroom to share targets to solve in the “area”. Based on the proposals and preferences of the students, we set “area” and made contents of the course. The first “area” set in the course was Shinagawa, where is adjacent of the school and the Shinagawa’s religious connection led us city of Fuchu where we had three excursions. During the summer break, we went Osaka to have a field excursion of three days and two nights.

In Osaka, we walked around the Uemachi Hills to watch its morphology and historical heritages and visited Shitenoji temple, which have a history longer than 1400 years. On the approach to the temple, the earth-science teacher explained the relationship with fault activity that uplifted the Uemachi Hills and a slope seen in west of the approach. After that, the teacher of Japanese history led students to watch historical building and a monument of Ansei Tokai Earthquake and tsunami (1854) in the temple. The monument was built by townspeople of the area to commemorate victims of the earthquake and tsunami. The students started to read epigraph on the monument and discuss on the content with teachers. A discussion on tsunami caused by the Ansei Earthquake was led by teachers of Japanese history and earth-science. After the visit to Shitenoji temple, someone proposed to walk and see other temples on the way down from the temple.

As shown in above, we eliminated barrier between subjects and the students realized that the things they were facing were mixture of history and morphology. The teachers gave general direction of the excursion; however, the teachers exchanged their roles with the students. The teachers and students both learned deeply and independently.

Keywords: field work, school education, area

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Desirable way of outreach activities in the Museum,learn by participating in the making process of "Buratamori".

*Inoue Motoko[1]

1. Saitama Museum of Natural History

To promote earth science,it's important to make the general public to feel familiar with earth science and see the fun of it .Promoting popular interest is one of the missions of Natural History Museum,but it is too difficult to satisfy all museum users who have various levels of geoscientific literacy.The stuff of TV show,"Buratamori”,gave me a clue to settle such problems.I learn 5 important viewpoint of outreach activities by participating in the making process of "Buratamori”.

1) We should understand the thinking process of the general public,who are not much interested in earth science.
2) We should summarize relevant information of various field (earth science,history,culture) in each local area,and associate it with the life of the general public.
3) We should focus more on familiar stories in the local area than theory to promote interest of the general public.
4) Simple and easy-to-understand explanation is more important than showing the accuracy of the study results.
5) It is important for us to show people that we enjoy learning earth science rather than showing our knowledge.

Keywords: Geoscientific literacy, Region, Interpreter

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Methodology of Geoscientific Outreach of “Buratamori”

*Takayuki Ogata[1]

1. Disaster Prevention Research Center for Island Regions, University of the Ryukyus

Buratamori produced by NHK contributes especially to geoscientific outreach and lifelong education for leaning on various geographical and geological topics. Such geoscientific topics related seamlessly with other contents on history, biology, agricultural and engineering sciences. Seamless geoscientific stories (geostories) are also produced in geoparks as a method for geoconservation, geotourism and geoscience education. Geostories require well-selected and arranged contents targeting historical, vertical and/or horizontal phenomena based primarily on many geoscientific evidences. Much many Japanese geoscientists also watch Buratamori because various topics are interpreted by many specialists on geography and geology. Geoscientists interest scientific evidences and interpretations on each specialties, and multidisciplinary and interdisciplinary relationships to other disciplines. Comprehensive and seamless stories of Buratamori enhance educational effects as a methodology for outreach and science communications, which are supported by geoscientific knowledges of many scientists, directors, producers and Mr. Tamori.

Keywords: Buratamori, outreach, geostory, lifelong education, geoscience, science communication

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General discussion 2

*Kazutaka Mannen[1]

1. Hot Springs Research Institute of Kanagawa Prefecture

We will discuss the way of outreach in geoscience.

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 10:15 AM - 11:25 AM JST | Sun. May 26, 2019 1:15 AM - 2:25 AM UTC | IC 2F

[O-02] Recent Advances in Earth and Planetary Science

convener:Tatsuhiko Hara(International Institute of Seismology and Earthquake Engineering, Building Research Institute), Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Yasuhito Sekine(Earth-Life Science Insitute, Tokyo Institute of Technology), Chairperson:Kou Yamada

This is an outreach session, in which invited speakers present their recent findings and developments in fields of earth and planetary sciences. This session has been presented as a public session since 2005. The JpGU Publicity and Outreach Committee members are conveners of this session.

10:15 AM - 10:50 AM JST | 1:15 AM - 1:50 AM UTC

[O02-01] The challenges of Asteroid Exploration Mission Hayabusa2 and its results up to now

★Invited Papers

*Makoto Yoshikawa[1] (1.Japan Aerospace Exploration Agency)

10:50 AM - 11:25 AM JST | 1:50 AM - 2:25 AM UTC

[O02-02] Earth's core revealed by ultrahigh-pressure experiments

★Invited Papers

*Kei Hirose[1,2] (1.Earth-Life Science Institute, Tokyo Institute of Technology, 2.Department of Earth and Planetary Science, The University of Tokyo)

The challenges of Asteroid Exploration Mission Hayabusa2 and its results up to now

*Makoto Yoshikawa[1]

1. Japan Aerospace Exploration Agency

As the follow-on mission of Hayabusa, the first asteroid sample return mission in the world, Hayabusa2 was launched in December 2014. While the main purpose of Hayabusa was demonstration of technology, the main purpose of Hayabusa2 is to do scientific researches. Particularly the important subject is to study water and organic matters that existed when the solar system was born. In addition to this, it is also an important purpose to establish more reliable technology for planet exploration based on the experience of Hayabusa, which had a lot of technological troubles.

After about three and half year space journey, Hayabusa2 arrived at Asteroid Ryugu in June 2018. At first, we observed Ryugu in detail by using remote sensing instruments on board, then we were successful to land small rovers and a lander on the surface of Ryugu. However, we postponed the touchdown to get the surface materials of Ryugu to February 2019 from October 2018 of the original plan. After the touchdown, we will carry out an experiment to make a small crater of the surface of Ryugu. Hayabusa2 will leave Ryugu at the end of 2019, and will return to the earth at the end of 2020.

The asteroid Ryugu, which has a shape of a spinning top and which is covered by a lot of boulders, is very interesting from the point of science. It is rather different from what we assume before the arrival.

In this presentation, we will talk about the challenges of Hayabusa2 based on Hayabusa and the scientific results up to now.

Keywords: Asteroid, Exploration, Solar system

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Earth's core revealed by ultrahigh-pressure experiments

*Kei Hirose[1,2]

1. Earth-Life Science Institute, Tokyo Institute of Technology, 2. Department of Earth and Planetary Science, The University of Tokyo

The interior of the Earth is under high pressure and high temperature. The condition at the center of the Earth is 364 gigapascals and about 5000 kelvins. Such extreme condition can be generated in a laser-heated diamond-anvil cell (DAC). Any materials existing inside our planet can be synthesized using this technique.

I will discuss the formation and evolution of the Earth’ s core on the basis of recent DAC experimental results. Our recent work has shown that the core composition has changed to a large extent since its formation by exsolving oxide and silicates. Such core-derived oxide and silicates may have caused “anomalies” presently observed in the deep mantle and core.

I will introduce the latest works on core formation and evolution as well as ultrahigh-pressure experimental techniques using a DAC.

Keywords: core, high-pressure, deep Earth

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 11:30 AM - 12:15 PM JST | Sun. May 26, 2019 2:30 AM - 3:15 AM UTC | IC 2F

[O-03] Poster presentations by senior high school students

convener:Tatsuhiko Hara(International Institute of Seismology and Earthquake Engineering, Building Research Institute), Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kou Yamada(Waseda University), Chairperson:Kou Yamada, Katsuyoshi Michibayashi, Hajime Naruse(Kyoto University), Keiko Konya, Miwa Kuri(東北大学災害科学国際研究所)

Senior high school students provide poster presentations on subjects in fields of earth and planetary sciences. This session provides an opportunity for senior high school students to give their presentations in the JpGU meeting and to have discussions with researchers. This session has been conducted as a public outreach session since 2006.

11:30 AM - 12:15 PM JST | 2:30 AM - 3:15 AM UTC

[O03-01] Poster presentations by senior high school students

[J] Oral | O (Public) | Public

[O-03] Poster presentations by senior high school students

convener:Tatsuhiko Hara(International Institute of Seismology and Earthquake Engineering, Building Research Institute), Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kou Yamada(Waseda University), Chairperson:Kou Yamada, Katsuyoshi Michibayashi, Hajime Naruse(Kyoto University), Keiko Konya, Miwa Kuri(東北大学災害科学国際研究所)

Sun. May 26, 2019 11:30 AM - 12:15 PM IC (2F)

Senior high school students provide poster presentations on subjects in fields of earth and planetary sciences. This session provides an opportunity for senior high school students to give their presentations in the JpGU meeting and to have discussions with researchers. This session has been conducted as a public outreach session since 2006.

11:30 AM - 12:15 PM

[O03-01]Poster presentations by senior high school students

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[J] Poster | O (Public)：Public

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_1

[O-03] Poster presentations by senior high school students

convener:Tatsuhiko Hara(International Institute of Seismology and Earthquake Engineering, Building Research Institute), Katsuyoshi Michibayashi(Department of Earth and Planetary Sciences, Nagoya University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kou Yamada(Waseda University)

Senior high school students provide poster presentations on subjects in fields of earth and planetary sciences. This session provides an opportunity for senior high school students to give their presentations in the JpGU meeting and to have discussions with researchers. This session has been conducted as a public outreach session since 2006.

[O03-P01] Factors of the famine of Aomori in the Edo era viewed from the Hirosaki domain diarty

*Masyu Sakamoto[1], *Mizuha Kamata[1], *Aten Noguchi[1] (1.Ikedagakuen Ikeda Senior High School)

[O03-P02] Visual monitoring and surface wind analyzing clarified the importance of sea and valley wind in causing sudden shower in mountain basin

*Aihisa Kamijo[1] (1.Geoscience Club, Matsumoto Fukashi Senior High School)

[O03-P03] The effect of coastal erosion on Shinmaikohama Beach

*Yuuto Yoshida[1], *Izuki Onoda[1], *Ayaka Saitou[1], *Issei Suzuki[1], *Haruto Komiya[1], *Toshiki Sasaki[1], *Daisuke Baba[1] (1.Fukushima Prefectural Iwaki High school)

[O03-P04] Consideration by Grave seismology

*Yuito Kaji[1], Kosuke Kobayashi[1], Kaname Ishida[1], Yasuhiro Suzuki[1], Kyoichiro Uehara[1] (1.Yashiro High School)

[O03-P05] Analysis of metal ion concentration in the rivers of Yosemite Valley and comparison with Japanese rivers

*Kaname Ishida[1], Noa Harada[1], Michihiko Kondo[1] (1.Yashiro High School)

[O03-P06] Magnetic measurement of basalt dikes in the Sara river of Tsuyama

*Hayate Madokoro[1], *Yuta Emi[1], *Syota Matano[1], *Naoyuki Washida[1] (1.Okayama prefectural Tsuyama High School)

[O03-P07] The Study of Seawalls Combined with Moats

*Toshiatsu Aoki[1] (1.Yokohama Science Frontier High School)

[O03-P08] Relationship between the seismic moment release rate in the Nankai subduction zone and the 2011 Tohoku earthquake

*Yoko Kono[1] (1.Yokohama Science Frontier High School)

[O03-P09] Automation of the self-made pinhole type planetarium projector

*Masami Kanno[1], *Asahi Komori[1], *Haruhito Nakamura[1], Kano Makiyama[1], *Munehiro Asao[1], *Ryo Kakegami[1], Akika Shimizu[1], Tomoka Kawamoto[1] (1.Yokohama Science Frontier High School)

[O03-P10] Capturing Blue-shift of Red Edge using the Spectrum of Earthshine -The Earth seen from the space-

*Noa Itou[1], *Ayami Yoshino[1] (1.Yokohama Science Frontier High School)

[O03-P11] Observation of Thundercloud

*Ayune Masuda[1] (1.Yokohama Science Frontier High School)

[O03-P12] A Historical Review of the Sky in Yokohama 1965 to 2014

*Rikako akai[1] (1.Yokohama Science Frontier High School)

[O03-P13] Seismic isolation system for furniture

*Tesshin Noma[1], *Syuntaro Hayashi[1] (1.Sakae-Higashi High school)

[O03-P14] How to use soil of school

*Hohoko Asahina[1], Honoka Oinuma[1] (1.Tokyo Metropolitan Tama High School of Science and Technology)

[O03-P15] Measurement of Cloud Cover at Night by Brightness

*Soyoka Okano[1] (1.Tokyo Metropolitan Tama High School of Science and Technology)

[O03-P16] Application of ion-exchange reaction in soil for desalination system

*Yushi Sato[1], Ryota Iizuka[1], Toya Nakano[1] (1.Tokyo Metropolitan Tama High School of Science and Technology)

[O03-P17] Investigation into agricultural utilization by the aluminum removal of the trass

*Yuto Miki[1] (1.Tokyo Metropolitan Tama High School of Science and Technology)

[O03-P18] Earthquake prediction by radio wave noise

*Sou - Yasuda[1], Ryosuke - Kiribuchi[1], Hiromori – Hayashi[1], Rinta - Yamada[1], *Aiku - Tanaka[1] (1.Tokyo Metropolitan Tama High School of Science and Technology)

[O03-P19] Construct quaking models by the geological structure varieties

*Kazuki Sugawara[1], *Hideto Sato[1], Shuya Yamaki[1], Masato Ono[1], Shun Suto[1] (1.Miyagi Rifu high school)

[O03-P20] Fe concentration measurement method in spring water

*Nozomi Kawaharata[1], *Yusuke Oba [1], Yuto Sasaki [1], *Tika Sakuma [1], *Rei Sato[1], *Siratake Kosuke[1], *Riku Sugawara [1], *Masaki Murayama [1] (1.Furukawa Reimi Junior and Senior High School)

[O03-P21] Cause of amateur radio failure in meteor radio observation and its substitution

*Shoki Yashima[1], *Kokoro Abe[1], *Azumi Sato[1], *Sora Endo[1], *Kokomi Sugawara[1] (1.Furukawa Reimei Junior and Senior High School)

[O03-P22] Spectroscopic observation of meteor using diffraction grating

*Soya Ito[1], *Atsuya Sugawara[1], *Tomoki Misao[1], *Shotaro Mino[1] (1.Miyagi Furukawa Reimei Junior and Senior High School)

[O03-P23] Predicting the sea level change in the Ariake bay through analysis of diatoms and pollens

*Ayuto Yamashita[1], *Shino Furuta[1] (1.Kumamoto prefectural Amakusa High School)

[O03-P24] Altering unused irrigation ponds to mitigate flooding, maintain habitats, and reduce maintenance burden

*Rikuto Fukushima[1], Nao Maeda[1], Reo Yoneyama[1], Yuki Takahashi[1], Hiiro Tabata[1], Koutaro Hayashi[1] (1.Hyogo Prefectural Kakogawa Higashi High School)

[O03-P25] Development of the equatorial telescope for from the beginners to the advanced astrophotographer at low cost

*Jun Ikeda[1], *Shimpei Iwasaki[1] (1.Kaijo Senior High School)

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*Tsuyoshi Enta[1], *Ryutaro Mitsui[1] (1.Kaijo Senior High School)

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*Kanta Takakura[1] (1.Kaijo junior and senior high school)

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*Shun Takada[1], Kotaro Takemura[1], Taio Koizumi[1], Hayato Ishiguro[1] (1.Sapporo Nihon University Senior High School)

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*Ryosuke Yanagisawa[1], *Yoshito Momoi[1], *Yoko Kamata[1], *Takumi Kamijyo[1] (1.Naganoken Suwa Seiryo Senior High School)

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*Aoi Takamori[1] (1.Naganoken Suwa Seiryo Senior High School)

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*Asaka Yokobori[1], *Rin Mita[1] (1.Gunma Prefectural Ota Girls' High School)

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*Shuka Ishitani[1], Miku Ōno[1], Fukuoka Eri[1] (1.Muroto High School)

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*Eri Fukuoka[1], Nanami Hashimoto[1], Yui Takemura[1], Hayato Nii[1], Taisei Hamada[1] (1.Muroto High School)

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*katsuki takana[1], *ren osaki[1], *ritsuki sugiura[1], satosi arita[1], syogo okayama[1], yuta sunaba[1], aoi hashikawa[1], ken hirooka[1] (1.Tottori Prefectural Tottorihigashi High School)

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*Yuna Miyachi[1], Arika Tsuji[1], Yuzuki Kobayashi[1], Sae Takami[1], Tatsuki Morikawa[1], Ryota Yamasaki[1], Yuto Umeda[1], Matsuki Rina[1], Nahoko Kubo[1], Yo Sayama[1] (1.Kyoto Prefectural Sagano High Scool)

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*Nahoko Kubo[1], Yo Sayama[1], Yuna Miyachi[1], Arika Tsuji[1], Sae Takami[1], Yuzuki Kobayashi[1], Yuto Umeda[1], Tarsuki Morikawa[1], Ryota Yamasaki[1], Rina Matsuki[1] (1.Kyoto Prefectural Sagano High School)

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*Yuzuki Kobayashi[1], Sae Takami[1], Rina Matsuki[1], Ryota Yamazaki[1], Yuto Umeda[1], Tatsuki Morikawa[1], Nahoko Kubo[1], Yo Sayama[1], Arika Tsuji[1], Yuna Miyachi[1] (1.Kyoto Prefectural Sagano High School)

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*Yo Sayama[1], Yuna Miyachi[1], Arika Tsuji[1], Sae Takami[1], Yuzuki Kobayashi[1], Yuto Umeda[1], Tatsuki Morikawa[1], Ryota Yamasaki[1], Rina Matsuki[1], Nahoko Kubo[1] (1.Kyoto Prefectural Sagano High School)

[O03-P40] Considering the recent landslide disasters in Japan -Movement of water in pedosphere-

*Rina Matsuki[1], Nahoko Kubo[1], Yo Sayama[1], Arika Tsuji[1], Yuna Miyachi[1], Yuzuki Kobayashi[1], Sae Takami[1], Tatuki Morikawa[1], Ryota Yamasaki[1], Yuto Umeda[1] (1.Kyoto Prefectural Sagano High School)

[O03-P41] Comparison of GSI map data with the surveying data by targeting Woods for Field Practice Owned by Sagano High School

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[O03-P42] Summary of our activities and the future direction in the Woods for Field Practice Owned by Sagano High School

*Takeshi Fujimoto[1], Ako Kinoshita[1], Rina Matsuki[1], Yo Sayama[1] (1.Kyoto Prefectural Sagano High School)

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*Koudai Fujino[1], *Kotaro Saito[1], *Yoshiki Kujiraoka[1], *Hyate Doi[1], *Ibuki Yasuda[1] (1.Saitama Prefectural Urawa High School)

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*Taiga Suzuki[1], *Haruki Otiai[1], *Keita Ueno[1], *Athushi Watanabe[1] (1.Nirayama HighSchool)

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*Akihito Oota[1], *Kouta Enomoto[1], *Maho Kubota[1], *Minako Nishijima[1], *Atsushi Watanabe[1] (1.Nirayama HighSchool)

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*Souta Kojima[1], *Mao Kubota[1], *Natsuki Yoneyama[1], *Takayuki Yamamoto[1], *Athushi Watanabe[1] (1.Nirayama HighSchool)

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*Yohei Yamamoto[1], *Yusuke Yoshimura[1], *Atsuhide Machida[1], *Syotarou Shinoda[1] (1.Saitama prefectural Kumagaya High School)

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*Shu Ishibashi[1], *Kyota Kono[1], *Kota Takeda[1] (1.Tennoji Senior High School Attached to Osaka Kyoiku University)

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*Ten Hayashida[1], *Mitsuki Komeda[1], *Miku Yamamoto[1] (1.Tennoji Senior High School Attached to Osaka Kyoiku University)

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*Mayuko Suzuki[1], *Mirei Okada[1], Suzuka Kanazawa[1], *Natsuko Okude[1], *Mio Sawai[1], *Meika Minami[1] (1.Tennoji Senior High School Attached to Osaka Kyoiku University)

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*Takaaki Ishimoto[1], *Ryota Suzuki[1], *Koichi Sato[1], *Yuki Yonemura[1], *Hajime Yamamoto[1], *Tatsuya Amamiya[1], *Shinya Amamiya[1] (1.Chuo University Junior and Senior High School)

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*Satoshi Yamamoto[1] (1.Hongo senior high school)

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[O03-P59] The formation age and environment of the Tubo River outcrop,Seki in Gifu prefecture, Central Japan.

*Yuya Yamada[1], *Keisuke Ohno[1] (1.GIZAN SENIOR HIGH SCHOOL)

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*Naoya Yamashita[1], *Shin Hirano[1], *Hayato Matsuyama[1], *Yuya Okubo[1] (1.Shizuoka Prefectural Iwata Minami High School)

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*Tomoya Ina[1], *Daisuke Suzuki[1], *Keito Tsutahara[1] (1.Shizuoka Prefectural Iwata Minami High School)

[O03-P62] generation of 3D model on the coast of Samejima,the sea of Enshu and detection of coastline by drones

*Eito Takagi[1] (1.Shizuoka Prefectural Iwata Minami High School)

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*Kaito Kotsuti[1], *Kosuke Shimano[1], *Haruto Sakachi[1], *Fuyu Tokuda[1], *Syunsuke Nagayama[1], *Hiroki Nemoto[1], *Towa Murakami[1], *Yuki Mimori[1], *Yasushi Wada[1], Takemi Ogawa[1], Eri Yoshida[1] (1.Ibaraki Prefectural Hitachi First Senior High School)

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*Ayane Kawai[1], Michio Kumagai[2] (1.Shiga Prefectural Ishiyama High School, 2.Authorised NPO Biwako Trust)

[O03-P66] Changing environments on the earth – first termination of overturning in Lake Biwa

*Hinata So[1], Michio Kumagai[2] (1.Shiga Prefectural Zeze High School, 2.Authorized NPO Biwako Trust)

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*Masaki Tsuji[1], Michio Kumagai[2] (1.Shiga Prefectural Zeze High School, 2.Authorized NPO Biwako Trust)

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*Koushi Hashimoto[1], *Haruka Ono[1], *Riku Nakaima[1], *Takeo Matsuda[1], *Yoshie Sawazaki[1], *Takako Yamashita[1], *Takeru Wakabayashi[1] (1.Otemae Senior High School of Osaka prefecture : the evening course)

[O03-P70] The Study of Kabutoyama

*Manami Nakazawa[1], *Masahiro Okuyama[1], Dai Iijima[1], Haruta Moriya[1], Ayato Watanabe[1] (1.Yamanashi prefectural Hikawa Highschool)

[O03-P71] Proposal of GEO-KAMISHIBAI that enhances the appeal of SANRIKU Geopark and conveys it in an easy-to-understand.

*Keisei Yasuhara[1], *Kana Kato[1], *Mizuho Gondai[1], *Arisa Okubo[1], *Haruto Kawasaki[1], *Mai Kawabata[1], *Seiya Yoshida[1], *Hitomi Kimura[1] (1.Mariento Chikyu Tanken Club Senior)

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*Nobuyasu Nagata[1], *Takuma Yoshizawa[1], Shintaro Umeda[1], Reiji Ohigashi[1], Mahiro Tajima[1], Ryuto Kubota[1] (1.Fujishima High School)

[O03-P73] Estimation of sedimentary environment of volcaniclastic deposit and location of craters in the Nomashi formation, Izu Oshima

*Kouki Aida[1] (1.Musashi High School and Junior High School)

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*Ryou Ito[1], *Shuta Aoshima[1], *Tomoya Mizutani[1], *Daichi Ishii[1], Yosuke Saito[1] (1.Tokyo Gakugei University Senior High School)

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Yuzaburo Takamura[1], *Momoo Hayashi[1], Moeka Yamagishi[1], Keisuke Nobutoki[1], Yuna Buma[1], Fuyuno Anpuku[1] (1.Ichinomiya High School)

[O03-P76] Observation of the dust storm over the polar cap of Mars

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*Taiga Hirozawa[1], Suguru Okada[1], Tomoki Suzuki[1], Tomohiro Shibayama[1] (1.Ichinomiya High School)

[O03-P78] Characteristics of lightning discharge that generated sprites

Kazuki KOJIMA[1], Nanami INOUCHI[1], *Misa NAKASUJI[1], *Yasumichi NAKAHAMA[1] (1.Kagawa Prefectural Sambommatsu High School)

[O03-P79] Get closer to the mustery of Sprites and Elves.

*Ayumu Nishihara[1], *Shogo Kawamura[1], *Hidetoshi Oka[1], Daichi Iriki[1], Shunsuke Nakao[1] (1.Prefectural Kochi Ozu High School)

[O03-P80] Prediction of the giant-squid movement around Japan using the dataset of ocean current and temperature.

*Yuka Koike[1] (1.Hiroo Gakuen Senior High School)

Factors of the famine of Aomori in the Edo era viewed from the Hirosaki domain diarty

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Factors of the famine of Aomori in the Edo era viewed from the Hirosaki domain diarty

The motive for the study

We focused on the weather attached to the dates recorded in the historical documents and we have restored the weather from the description of the weather recorded in the four historical documents written in the Edo period.This year, we analyzed the Hirosaki domain diary.

The purpose of the research

(1)We will make a database together with the historical documents we examined in previous years.
(2)We will explore the effects of climate change that caused famines in the Edo period.

The research method

We defined the weather of days which were cloudy more than 90% of the day (more than 21.6 hours) as cloudy, and the weather of those cloudy for less than 90% of the dayas sunny.
Words that gave information on meteorological conditions other than the weather- “Thunder”, “Wind”, “Chilly・Cool” - were also counted.The data about the weather for 164 years (58, 781 days) has been gathered.

Data#1

We research the appearance rate of sunny days in the period of the Houreki famine suddenly fell.
It is said that the harm caused by the cold occurred in the Tohoku region as famine.
Also, the rate of rainy days in the Tenpoh famine period exceeded the appearance rate of fine weather.It is said that the cause of the Tempo famine was heavy rains, floods, and the accompanying cool summer.As shown in the graph, it is thought that the rain appearance rate was high and the amount of sunshine decreased, leading to famine.
The appearance rate of snow was at least 9.3% in 1768 and 29.9% in 1706.Mount Asama erupted in 1706.
The Kyoho famine and the Horeki famine are said to be famines caused by cool summers in western Japan, and the appearance rates of fine weather support it.

Data#2

Since the influence of,the “Yamase” - the cold, wet, east wind - was seen in the year of the Tenmei famine, 1787, it is considered to be a year when the impact of the Okhotsk Sea High Pressure was strong.

Data#3

If we look at the proportion of thunder in each season, “Heat thunder” occurs in the summers during the 30-year-period when the appearance rate of sunny weather was high.Because the proportion of thunder in winter was high in the 30 years of the Tenpoh famine, it is thought that thunder occurred because cold air flowed from the Siberian air masses.

Data#4

Between 1776 and 1789, when there was the Tenmei famine, the wind from the east, that is, the number of days of winds considered to be “yamase”, were many.Yamase is a cold,wet,east wind,that blows in summers mainly in the Tohoku region's Pacific side.

Date#5

We examined the record of “chilly” and “cool” days during the summers from June to August recorded in the Hirosaki domain diary.

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There were 459 days in the summers from 1701 to 1864 that were reported as “chilly” or “cool”. The word “cold” was not written in the records.

Discussion

(1)It is said that the Kyoho famine was due to the occurrence of delphacidae insects and a long period of rain in west Japan, but this influence was not seen in Aomori, where the appearance rate of fine weather was high.
However, from data#1, it is considered that famine only occurred in the period of the Houreki famine as the appearance rate of sunny weather declined.
(2)From the data #2, #4, the background of the Tenmei famine is that the Okhotsk Sea High Pressure was strong, the “Yamase” wind blew, and the Okhotsk Sea air mass influenced the number of thunder occurrences.
(3)From the data #1,#3,the 30 years including the Tenpoh famine period are considered to have the highest rate of rain, and low temperatures.Especially in the winter, it was affected by the Siberian Air Masses.

Summary of the study

(1)It is said that the Kyoho famine was a famine mainly of western Japan, and considered that the fluctuation of weather in Aomori was small, as the appearance rate of sunny days in the 30 years was high.
(2)In addition to the high occurrence rate of sunshine, the five years of the Horeki famine were linked to frequent thunder as the cold air flowing in the upper regions of the sky caused an unstable atmosphere. This caused famine in addition to declining sunshine hours.
(3)During the period including the Tenmei famine, the high pressure of the Sea of Okhotsk developed and "Yamase“wind occurred. It is considered that the cause of the famine was that the summer temperatures did not rise.
(4)The rainfall rate of 30 years including the Tenpo famine exceeds the appearance rate of sunny days. Due to the decline in sunshine hours, temperature drops also resulted in famine.

Keywords: The Hirosaki domain diarty, famine, yamase

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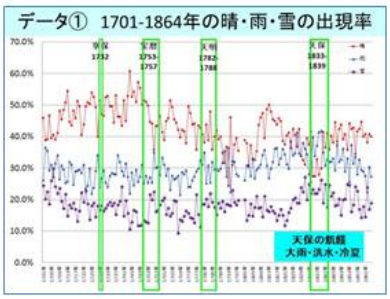
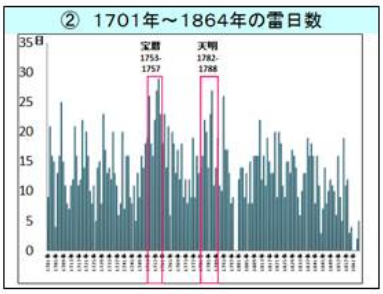
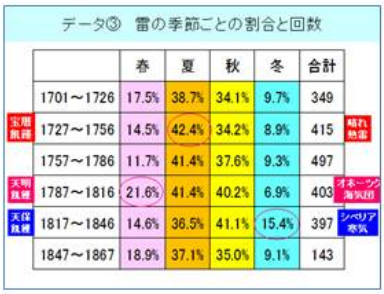
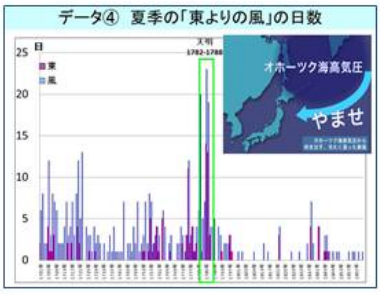


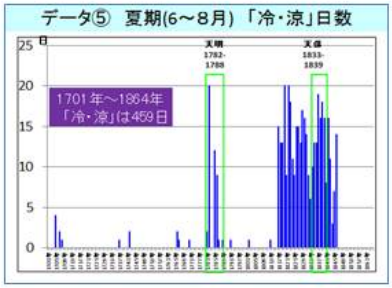




	春	夏	秋	冬	合計
1701～1726	17.5%	38.7%	34.1%	9.7%	349
1727～1756	14.5%	42.4%	34.2%	8.9%	415
1757～1786	11.7%	41.4%	37.6%	9.3%	497
1787～1816	21.6%	41.4%	40.2%	6.9%	403
1817～1846	14.6%	36.5%	41.1%	15.4%	397
1847～1867	18.9%	37.1%	35.0%	9.1%	143

宝暦飢饉 晴れ 地雷
天明飢饉 オホーツク海高気圧
天保飢饉 シベリア寒気





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Visual monitoring and surface wind analyzing clarified the importance of sea and valley wind in causing sudden shower in mountain basin

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Matsumoto basin is a mountain basin located 180 kilometers west-northwest of Tokyo. The Northern Japan Alps is a mountain range which is located on the west side of the basin, and a river valley leads into the southern part of the basin. In this basin, east-west-lined shower clouds occasionally occur and move to the north, causing sudden showers. I decided to study the relationship between sudden showers and surface wind through long-term visual monitoring, in addition to analyzing AMeDAS (Automated Meteorological Data Acquisition System) data.

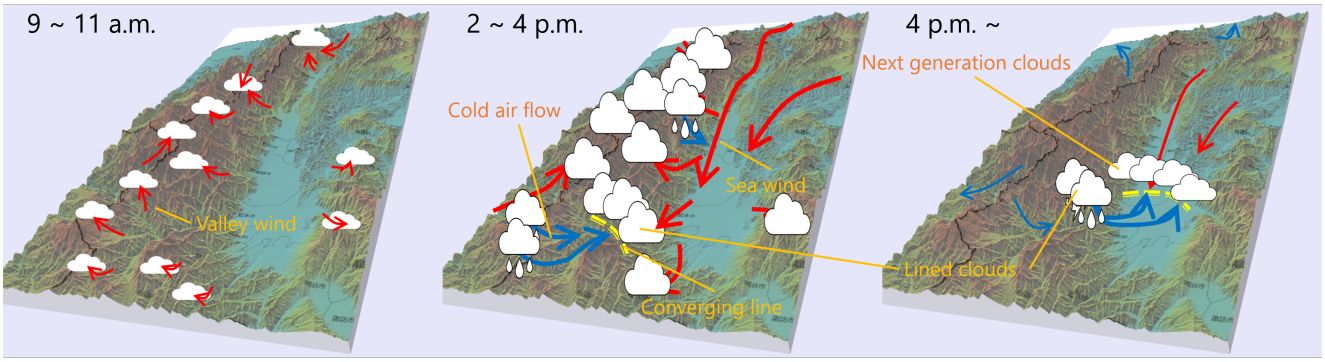
From July 11 to September 4, 2018, time lapse cameras at 5 points around the basin monitored the clouds. The surface wind patterns were classified using the shortest path algorithm from the data taken at 22 AMeDAS points around the basin from 2010 to 2017. The relationships between the states of clouds and the wind patterns have concluded that cloud formation on the ridge is caused by the valley wind.

From August 9 to August 16, 2018, daily changes in atmospheric instability were observed on the 2,310 meter high mountain ridge. These changes have shown that the development of the clouds on the ridge is caused by moist air brought by the sea and valley wind, which makes the atmosphere on the ridge unstable.

The monitored and radar-detected precipitation data showed that the cloud lines are caused by convergence of cold outflow from the clouds above the mountains and the warm, moist sea wind. This lined clouds moves to the north because it also causes cold outflow and form a new line toward the north, the direction from which the sea wind comes.

A similar pattern is also found in Phoenix, Arizona which is in a basin surrounded by mountains and also has effect of the sea wind in rainy season, with sudden showers caused by the same mechanism as in Matsumoto basin. Therefore, this mechanism can apply to showers in any other mountain basins.

Keywords: sudden shower, mountains, sea wind



A) Development of valley wind and Formation of clouds on the mountain ridges

B) Blowing of sea wind into Matsumoto basin and Beginning of sudden shower on the ridge

C) Cold air flow by lined shower clouds and sea wind cause new lined clouds.

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The effect of coastal erosion on Shinmaikohama Beach

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The treatise of Mr.Kobayashi Akio said that Shinmaikohama Beach in Fukushima is being eroded by waves.

So we examined to understand the situation there by measuring the altitude between points, and figuring out how to solve this problem.
We have been measuring the east and north-east from an object made of concrete.

Looking at the results we found that the north-eastern points were eroded more than the eastern ones.

There are blocks that clash with waves in the east.

There are not any these in the north-east.
In addition, after the spring tide, the influence of erosion is bigger than other things.

Keywords: Coastal erosion

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Consideration by Grave seismology

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The gravestone seismology is the study that considered the mechanism of the earthquake by investigating the gravestone. We started the research because we thought we could understand the geology of the epicenter by using grave seismology. In particular, the points that we investigated are in the North of Osaka and Hokkaido Eastern Iburi.These points were damaged by very big earthquake. And we have some consideration through the fieldwork. The problem was how to treat relations of disaster situations of differences each regions and geology, and the geological features in our home town from the case past “Zenkoji Earthquake “. What we can learn from the past, how the present is, and what we should do in the future. These are our study that considered Grave seismology.

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Analysis of metal ion concentration in the rivers of Yosemite Valley and comparison with Japanese rivers

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1. Yashiro High School

At our high school, we had overseas training in the United States as SSH field study from 2011. One of the training places was Yosemite National Park. We gathered water in several places from rivers around the Merced River, which flow into it and analyzed the concentration of underwater metal ions. We cooperated with Shinshu University, Faculty of Engineering, and Mechanical Systems Engineering. We examined the connection between the length of rivers and the concentration of underwater metal ions and compared the metal ions that are included in Japanese rivers and Yosemite National Park’ s.

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Magnetic measurement of basalt dikes in the Sara river of Tsuyama

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1. Okayama prefectural Tsuyama High School

According to previous studies, there was a warm archipelago, like that of the subtropical zone, in Tsuyama city about 16~7million years ago. In this study, we call the archipelago "the Tsuyama Sea". However, no one has precisely examined factors and dates of the disappearance of the Tsuyama Sea. We measured paleomagnetism of the basalt dikes which are stretching north and south in the Tsuyama Sara River with our own astatic magnetometer. By this measurement, the paleomagnetism showed that magnetic north was shifted 2.4˚ north-west from the current magnetic north when the dikes had been formed. Therefore, we think that an increase of the north and south compression caused the rising of the backbone range, and after that, the disappearance of the Tsuyama Sea.

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The Study of Seawalls Combined with Moats

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1. Yokohama Science Frontier High School

Tsunami of The Great East Japan Earthquake caused a lot of damages to Tohoku area. Nowadays, people make very high seawalls which can prevent our town from tsunami. Those seawalls are very important for protecting our lives. However, by doing so, those seawalls destroy the scenery and damage to tourism. To solve this problem, my research suggests new seawalls that combined with moats.
I make seawall model by using Styrofoam and aquarium. And I generate wave and hit to the seawall. This experiment control depth of the moat.

EXPERIMENT 1
At first, I examined how much depth was effective. I changed depth (0,5,10,15cm) and corrected each 5 data. As a result, I couldn’ t get certain data that showed how much depth was the moat. However, it was found that the reaching distance of the wave can be reduced more if there is a moat than there is no moat.

EXPERIMENT 2
Second, I experimented on only5cm depth 48 times to increase the number of data. Using this result, I created a scatter plot(X : Height of wave Y : reaching distance of wave) and an approximate straight line (y=1.9592x-33.27 Correlation coefficient is 0.73).

I changed the effect of the moat to a lite size by using this formula. As a result, I could prove seawalls combined with moats were stronger than before.
However, this experiment have some problems. For example, this experiment have many variables. So it is difficult to expect the result when experimental condition is changed.
In the future, I’ m going to use PC to simulate a lot of case.

Keywords: Earthquake, Tsunami, Seawall

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Relationship between the seismic moment release rate in the Nankai subduction zone and the 2011 Tohoku earthquake

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1. Yokohama Science Frontier High School

To investigate the impact of the 2011 Tohoku earthquake to the slip at the transition zone on the plate interface in the Nankai subduction zone, we have examined the temporal variation in the seismic moment release rate in the periods with no long-term slow slip events before and after the 2011 Tohoku earthquake for six areas, the northern, the central and the southern Kii, and the eastern, the central and the western Shikoku. We used the data of the seismic moment of slow slips estimated by the empirical relationship between the apparent moment of deep low-frequency tremors and short-term slow slips during April 2002–July 2013 [Daiku et al., 2018] and newly analyzed data during August 2013–February 2017. We estimated the seismic moment release rates before and after the 2011 Tohoku earthquake using the nonparametric bootstrap method for each area.
We recognize no significant variations in the seismic moment release rate before and after the 2011 Tohoku earthquake for the northern and the southern Kii and the eastern, the central and the western Shikoku areas. These variations are coincident with no significant coulomb stress change induced by the 2011 Tohoku earthquake in the Nankai subduction zone [Toda et al., 2013]. On the other hand, for the central Kii area, the seismic moment release rate decreases significantly after the earthquake. However, the decrease is also observed even before the earthquake. We, therefore, consider that the decrease is not likely to be affected by the 2011 Tohoku earthquake.
From the results mentioned above, we conclude that the 2011 Tohoku earthquake does not affect the seismic moment release rate at the transition zone in the Nankai subduction zone. However, there is a possibility that, in the central Kii areas, together with the southern Kii area before the 2011 Tohoku earthquake, a frictional condition at the transition zone might have varied gradually with time.

Keywords: Earthquake, Deep low-frequency tremors

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Automation of the self-made pinhole type planetarium projector

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1. Yokohama Science Frontier High School

In the “Seisakuhan” of our school's astronomy club, we project planetariums in school festivals and astronomical classrooms for the local residents, and have gained much popularity. However, there is a problem that it is difficult to perform various projections by changing the season or time zone in order to turn the projector manually. Therefore, in order to diversify the projection, we aimed to automatically rotate the projector using commercially available materials.
First, when rotating the projector automatically, it was decided at what speed to rotate it once. As an indicator, we manually turned the projector one turn at a speed that made us not uncomfortable. The results were averaged to set 28.7 s as the target time. Next, we discussed the mechanism to automate the projector. Got an idea from the movement of the caterpillar, we decided to rotate the projector using a motor-powered gearbox and belt. In order to rotate the projector at the target time, the gear ratio of the gearbox was changed and the time at each gear ratio was measured. By changing the gear ratio, it is thought that the rotational speed and rotational torque change, so that the power of the gearbox changes and the rotational speed of the projector changes.
As a result, in the gear box used this time, it became 8.5 s by gear ratio 1300.9: 1 which rotation speed becomes the smallest. This time was the longest time measured with other gear ratios. However, the target time of 28.7 s was not reached. Therefore, by changing the applied voltage from 3V to 1.5V with a gear ratio of 1300.9: 1, it was considered that the rotation time would be about 17s, which is doubled from 8.5s. As a result, the projector did not rotate and did not reach the target time.
This is considered to be due to the fact that the motor did not operate well at 1.5 V because the proper voltage of the motor was 3 V.
Future prospects include improvement of belt slack, measures for motor drive noise and discussion of how to reduce of rotational speed.

Keywords: Planetarium

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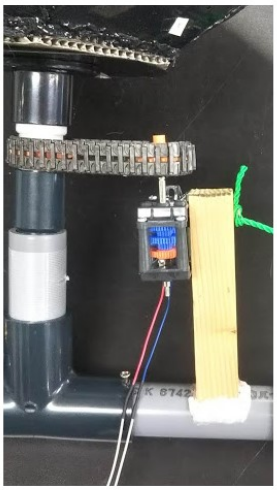

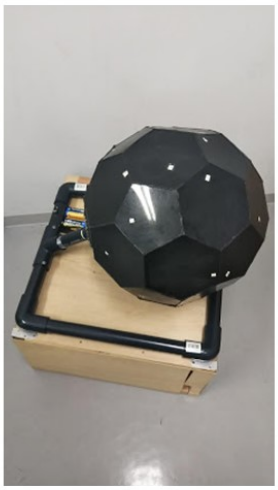

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Capturing Blue-shift of Red Edge using the Spectrum of Earthshine -The Earth seen from the space-

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1. Yokohama Science Frontier High School

The purpose of this study is to find out geochemical abnormality such as mineralization zones of the earth from the ground by observing the blue-shift thorough a spectrum of the earthshine.
The earthshine is the astronomical phenomenon of sunlight reflecting from the earth’ s surface and illuminating the dark side of the moon. Sudden increase in reflectance of the red wavelength in the reflection spectrum of the plant is called a red edge. Blue-shift means that a red edge shifts to the blue wavelength side when a plant felt stress.
In this study, observation of the earthshine using the telescope and a plant experiment on the ground were performed.
As a result , in the observation of the earthshine , detecting a red edge is succeeded but the blue-shift was indistinct. In the experiment of the plants , a blue-shift was seen in the red edge of the plant gave water stress. However a blue-shift was indistinct in the plant brought up with solution of the heavy metal salt.

Keywords: Earthshine, Spectrum, Red Edge, Blue-shift

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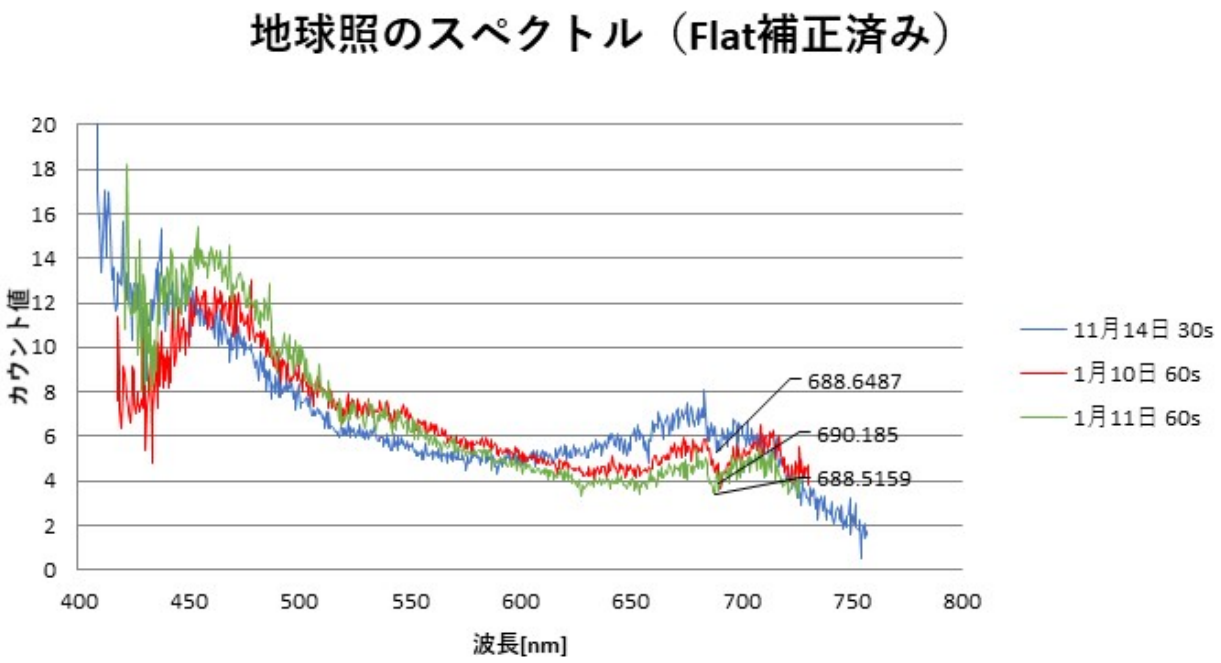

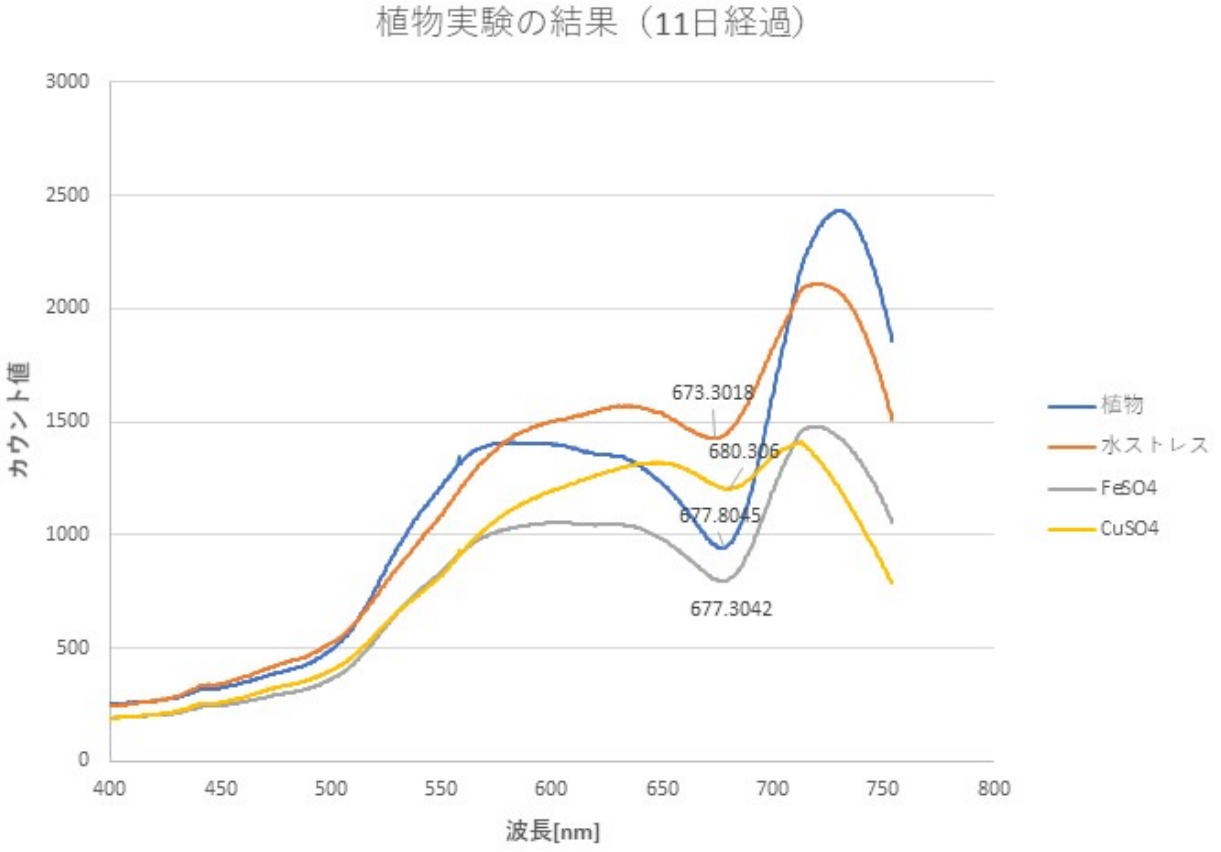

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Observation of Thundercloud

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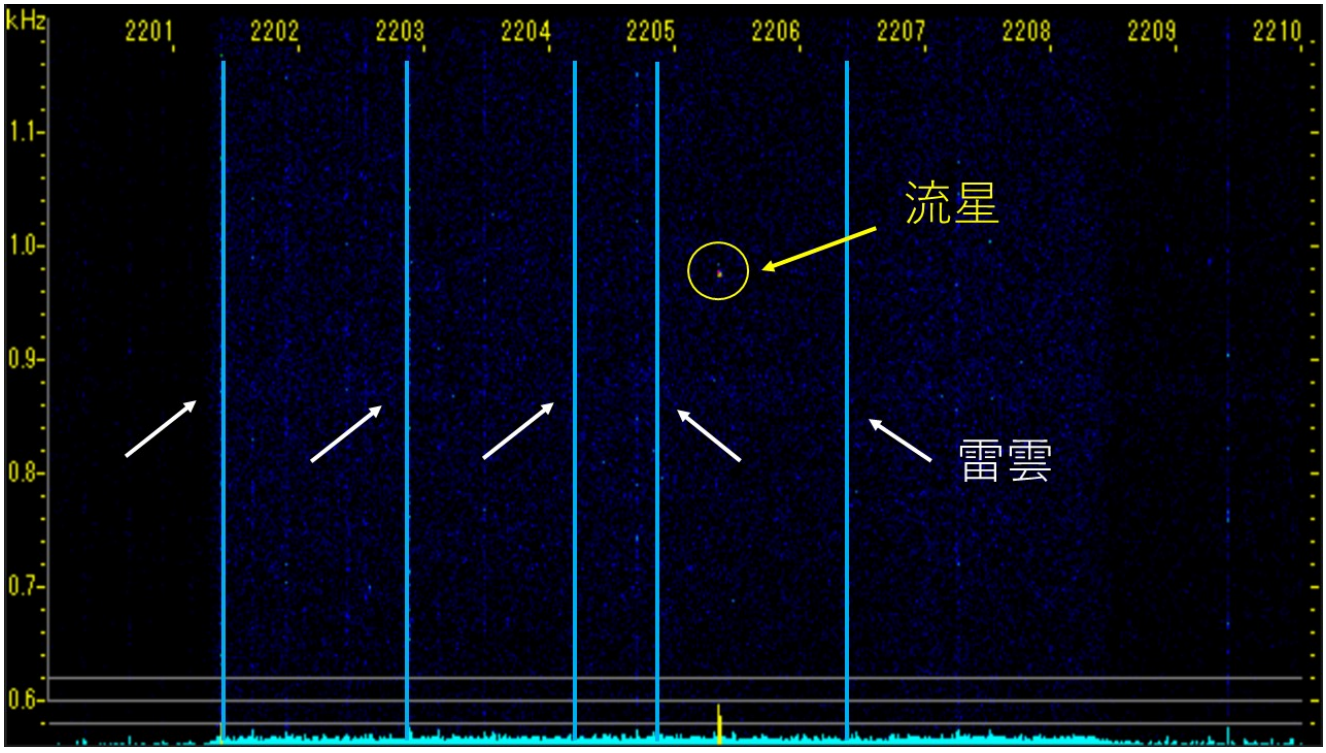
Now, there are many methods to predict the thundercloud, but they are very abstract. I think if we can predict easily, it may lead to the awakening of lightning accidents. Then I observed a thundercloud by using electric waves. It’ s the system of observation. A thundercloud can reflect electric waves, and I can observe it by catching electric waves. I used the frequency of 53.755MHz and the AM radio. We can use those frequencies easily. There is a method to observe it as noise by the preceding study. But I think only noise is difficult to observe in a thundercloud, so noise are changed the image, it becomes easy to observe a thundercloud. I used a software called HROFFT.
It can change sound data into an image. This is the image. X axis is time and Y axis is frequency. The pattern other image is changed by something. For example, a dot is made by a shooting star and a curve line is made by an airplane. A thundercloud makes a bar line. In this way, if a bar line appears in this image, we can know that there is a thundercloud. I couldn’ t observe a thundercloud by using 53.755MHz in Yokohama because it didn’ t occur, but in Niigata Prefecture, I could observe it and identified on the image. The other hand, I couldn’ t observe it by using the AM radio in Yokohama because there were too much noise to identified on the image.
I found that the cause which I couldn’ t observe it is noise. Then I’ ll try to remove noise from the image. I have two kinds. First, I miss an extra electric current outside. Second, I control the receiver sensitivity. Eventually we will be able to use this system everywhere.

Keywords: Thundercloud, Electric waves



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A Historical Review of the Sky in Yokohama 1965 to 2014

*Rikako akai[1]

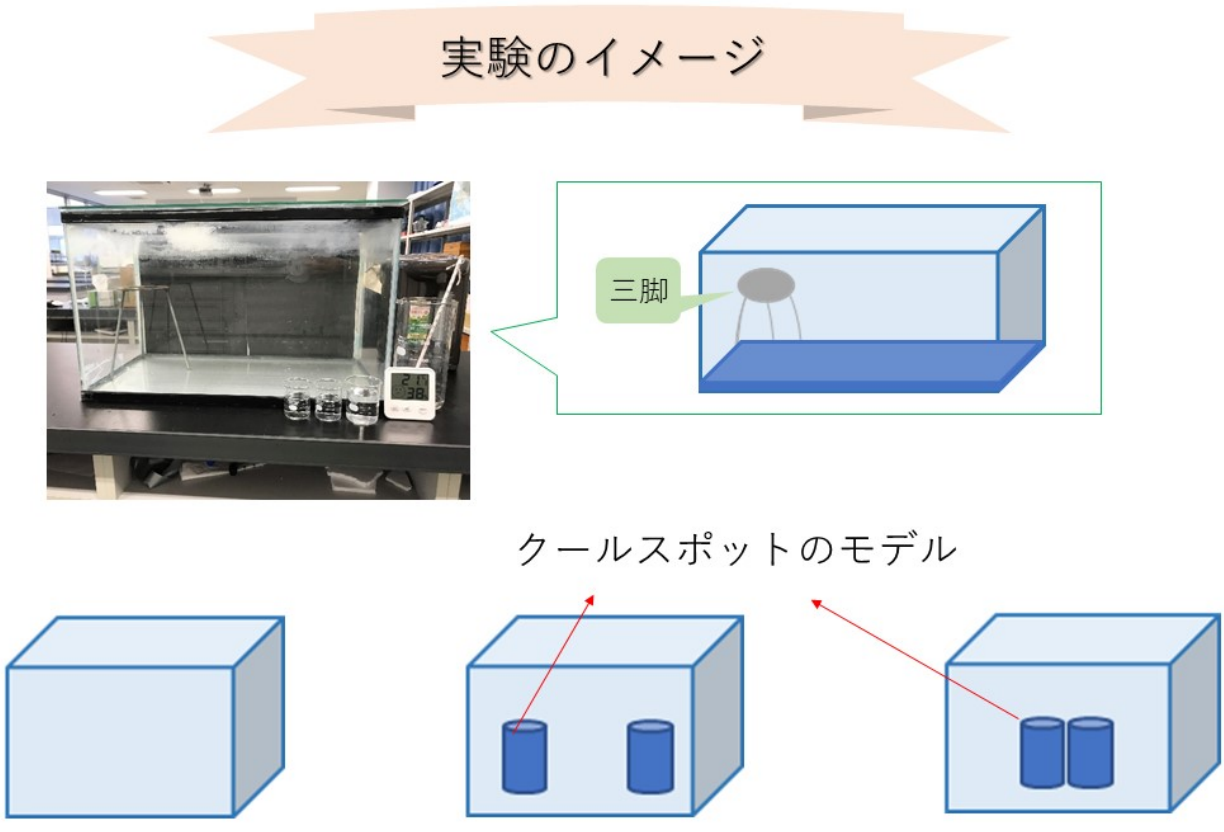
1. Yokohama Science Frontier High School

This is the research of climate change in Yokohama to solve environmental issues in Yokohama.

First, I analyzed weather data of 1965 to 2014 in Yokohama. As a result, I found 4 points; the rise in the temperature and humidity; the increase in cloud cover and precipitation and the number of days of thunderbolts; the decline in the greenery rates; the decline in the number of days of fog. We can think these are because the temperature was raised. Because of these results, I thought the heat island phenomenon has been occurring in Yokohama.

Second, I thought making cool spots is the best idea to provide effects of the heat island phenomenon. So, I did an exmeriment to know the efficient way of locating cool spots. From the results of the experiment, I knew that putting cool spots separately is the efficient way.
In the future, I want to continue this experiment and looking for the places to put cool spots in Yokohama by using actual maps.

Keywords: Climate Change, The Heat Island Phenomenon , Control Experiment, Environmental Measure



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Seismic isolation system for furniture

*Tesshin Noma[1], *Syuntaro Hayashi[1]

1. Sakae-Higashi High school

Recently, seismic isolation systems are used many as an earthquakes measure for high-rise buildings. Then I thought that I wanted to show the good effects for tall furniture so I started this study.

According to Teraya and etal. (2015), the two bookshelves as shown in Table.1 turn over at 0.6Hz and 1.0Hz when the flooring is carpeted and in the case of flooring, acceleration tends to increase at 0.6Hz. So, the frequency that tall furniture falls easily is from 0.6Hz to 1.0Hz.

In this study, I used a seismic isolation system which replicated soft material and hard material. I thought that if an earthquake frequency is reduced them, furniture would not fall. This study’s goal is to find materials which can do that.

I used two kinds of seismic isolation systems as shown in Table.1. I put four seismic isolation systems under two different models of tall furniture. This is shown in Fig.1.

I measured acceleration with three smartphones like Fig.1 using the application: “Acceleration Logger” by Naoki Kisara. I moved the experimental equipment in the direction of the arrow in Fig.1, and used the Fourier formula to convert the data which I measured on each model. Then I made graphs of the magnification of the magnitude of the quake. I divided one data which one model used my seismic isolation system by another data didn’t. This is shown in Fig.2.

In Fig.2, when magnification of a certain frequency was more than 1, I substituted +1 for the frequency and if it was less than 1, I substituted -1 for the frequency. I measured them 30 times in this way. Fig.3 is the graph of the total of the values that I substituted for every frequency.We call this way SS method “Sign Sum”.

In the case of seismic isolation system 2, magnitude of the quake is reduced at 1.0Hz. This combination shows the good effect for tall furniture around 1,800 millimeters.

In the future I want to look for a better material or combinations from the viewpoint of hardness of the material.

Keywords: earthquake, seismic isolation system, furniture

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表 1.家具と免震装置の詳細

Table.1 Details of furniture and seismic isolation system.

	寸法(mm) (幅×奥行き×高さ)	質量(kg)	備考	出典
本棚 1	900×300×1800	32.0	棚板耐荷量 20kg 地板は転倒防止の為 80mm 前方に突出	寺屋・他 (2015)
本棚 2	450×290×1800	18.5	棚板耐荷絵量 10kg	寺屋・他 (2015)
免震装置 1	50×50×25	0.1	2.0mm のゴム＋0.5mm のアルミ	本研究
免震装置 2	50×50×25	0.04	2.0mm の発泡 P.P＋0.5mm のアルミ	本研究

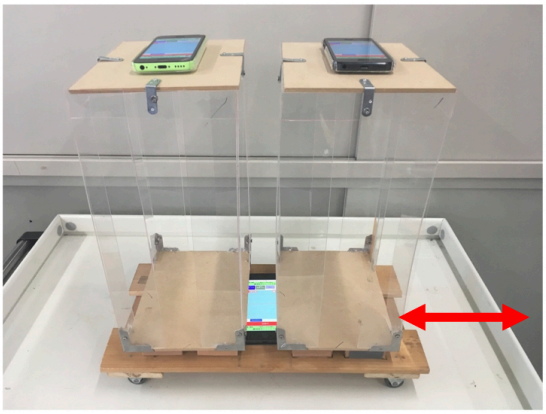

図 1 .家具の模型として作った実験装置

Fig.1 Experimental equipment which was made as models of furniture.

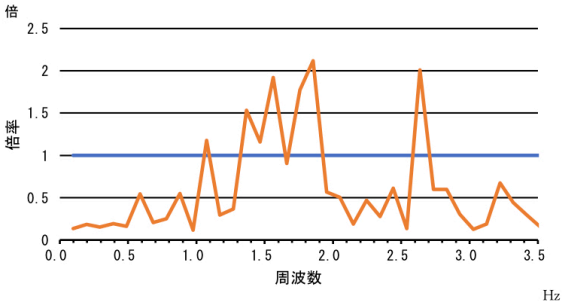

図 2 .免震装置を使用していない方に対する、

使用している方の加速度の倍率のグラフ(例)

Fig.2 Example of graphs of the magnification of the magnitude of the quake.

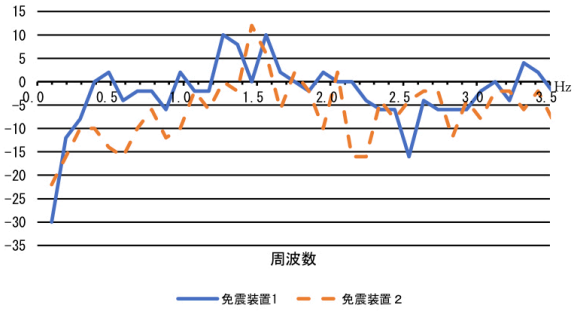

図 3 .SS 法で集計した結果

Fig.3 Graph of counting by SS method.

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How to use soil of school

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1. Tokyo Metropolitan Tama High School of Science and Technology

More and more public schools are being abolished in recent years. The number of schools abolished is 6,811 from 2002 to 2015. Above 1,700 school facilities are unused . We started our research with the purpose of finding out how to utilize soil in schoolyards. To do so we make comparison between the soil of fields and of schoolyard using EDS and WDX. In conclusion the soil in schoolyards is short of nutrition so plants do not grow.

Keywords: Soil, Abolished School

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Measurement of Cloud Cover at Night by Brightness

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Background

The weather status in Japan is decided based on the cloud coverage. However, as cloud coverage is measured with our own eyes, it is not always accurate. Therefore, in order to improve the accuracy of weather forecast this research was conducted aiming at establishing a new method to measure cloud cover accurately using SQM (Sky Quality Mater: SQM is the observation equipment which measures night empty brightness. The higher than numerical value is the darker the sky is).

Also, safety increases when the night flight understands the thickness of the cloud beforehand. However, the thickness of the night cloud can be measured in only infrared rays. It is not correct. I thought measurement of the cloud coverage and thickness of the cloud at night by brightness.

Method

Experiment1, measurement of the cloud coverage and pollen at night by brightness.

The brightness at night was measured with SQM at two minutes interval. I set SQM on the roof of our school (Honnmachi, Koganei, Tokyo). Based on the data provided by the Japan Meteorological Agency, the sunny days (Cloud cover - 0), the cloudy days (Cloud cover - 10) and pollen’ s day of the day of the new moons were selected. Graphs were drawn using the data collected from 8 p.m. to 3 a.m. (the time with no influence of sunlight) on the days which met the conditions given above.

Experiment2, measurement of the cloud of the thickness.

I prepared two boxes different in the size. I assumed the name of the box A (300mm*300mm*300mm) or B (300mm*300mm*600mm). I put liquid nitrogen in a box and produced steam. I use a darkroom to make the situation same as a night town.

I set up light under the box.I measured volume of light that reflected in SQM.

Experiment 3:change of the brightness due to the pollen.

I put pollen of the ragweed in the box.

In the same way as experiment 2,I measured the light that pollen reflected.

Experiment 4:Transmission spectrum of the pollen

I checked whether a pigment of the pollen absorbed light. I smashed 1g of pollen of the ragweedwhich I used in experiment 3 in phosphate buffer solution.

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I was multistoried on 2.3M sucrose and ran to a centrifuge (1, 000* g) for 20 minutes. I measured transmittancy of the light (250-550nm) with a spectrophotometer with a supernatant provided by centrifuging.

Result

Result 1

As for the clear weather, a high value was provided through the whole in comparison with cloudy weather. From this, I understood that it was dark in the clear weather night.

Result 2

Both boxes had a smaller numerical value of SQM than an empty box. The numerical value of box B had lower numerical value of SQM than box A. From this, I understood that a lot of box B reflected light.

Result 3

It was seen that the contained box of the pollen said that numerical value of SQM was higher than an empty box. From this, I understood that a contained box of the pollen was gloomier.

Result 4

The pigment of the pollen understood that it absorbs in a color (350-500nm) of the

blue of something. It is thought that the reason why pollen absorbed light by experiment 3 is that I used light of the white. In addition, it is thought that I am uneven in a change of the volume of light when the light of the night town measures the light of the night town using SQM in spring and summer.

Keywords: cloud covreage, atmosphere, weather, Sky Qyality Mater, pollen

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Application of ion-exchange reaction in soil for desalination system

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1. Tokyo Metropolitan Tama High School of Science and Technology

Nowadays, water shortage is serious problem around the world, so many countries use desalinating system to make fresh water from seawater. But it is not used in developing countries, because it takes very high cost. Therefore, to make a new desalinating system, we used peat and volcanic ash soil in my research. They have an ability of adsorbing ions and we thought that it might adsorb the sodium ion and chloride ion from sea water.

Keywords: watershortage, desalination of seawater, ion-exchange ability of soil

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Investigation into agricultural utilization by the aluminum removal of the trass

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1. Tokyo Metropolitan Tama High School of Science and Technology

In Japan, 25% of the land is volcanic ash soil. The main constituents of volcanic ash soil are Fe and Al, which are low in nutrients and microbes and tend to be acidic. Al is dissolved in acidity and chemically combined with P added as fertilizer to form AlPO 4. AlPO4 does not become nutritional. Also, Al damages plant roots. In order to solve this problem, this study aimed to remove Al from volcanic ash soil. This time, we investigated the basic survey of the soil and how much Al could be dissolved from the soil.

Keywords: Soil improvement, Volcanic ash, Allophane

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Earthquake prediction by radio wave noise

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The purpose of this reseach is Earthquake prediction.

Also we clarify about electromagnetic phenomenon of emission source.

This technology is needed to reduce the victims of big earthquakes by warning them ahead of time.

VHF band are used to collect electromagnetic noise which can be used to tell if electrical discharges and pressure builds up in the earths crust. When an observation point shakes big, the base level of the radio wave noise tends to fall.

Keywords: Earthquake prediction, electromagnetic noise

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Construct quaking models by the geological structure varieties

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1. Miyagi Rifu high school

The Rifu-Nagamachi fault is known as a huge active fault in Miyagi prefecture area. My school is just standing on the fault. Our school geoscience team searched the boling core samples which was taken when our school constructed. Then we found numerous volcanic ash layers among the sediment sand-grain layers.

After we observed the layers, in order to mention what would be happen when the earth quake with fault activity occur, we constructed the geologic model with some cookies and chocolate chips. Our seismic model has not only sediment simulation, but also constructed electric-controlled quaking model, and observed the soil breakings. We investigated the ground - building affection with thinking number of the ash layers.

We observed the quaked soils with numerous ash layers among the sediment sands are more break, but more stable sink condition.

Keywords: Nagamachi-Rifu Fault, Quaking model, Kitchen Seismology

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Fe concentration measurement method in spring water

*Nozomi Kawaharata[1], *Yusuke Oba [1], Yuto Sasaki [1], *Tika Sakuma [1], *Rei Sato[1], *Siratake Kosuke [1], *Riku Sugawara [1], *Masaki Murayama [1]

1. Furukawa Reimi Junior and Senior High School

This research is to develop and verify a method to measure iron concentration in spring water using citric acid.Spring water is called "sekisui " because it contains a large amount of iron and turns red by the oxidation of soluble iron and iron ions in water.Sekisui has had effects such as crop growth failure and deterioration of river water quality.We know that iron and citric acid contained Sekisui will temporarily turn yellow due to the reaction, and we have arrived at this study because it is possible to measure the iron concentration by applying this method. Mix citric acid with sekisui to make it yellow. Then mix a commercially available yellow liquid with citric acid and light it to measure the illuminance. There is a difference in illuminance by changing the ratio of sekisui and yellow liquid. It is possible to generate regularity by generating the data in a graph. It is the research which measures the concentration of iron using the difference.

Keywords: Water quality, Iron

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Cause of amateur radio failure in meteor radio observation and its substitution

*Shoki Yashima[1], *Kokoro Abe[1], *Azumi Sato[1], *Sora Endo[1], *Kokomi Sugawara[1]

1. Furukawa Reimei Junior and Senior High School

We observe radio waves of meteors using radio waves of the VHF omnidirectional radio signal VOR and radio waves of the amateur radio HRO. However, in the HRO we used conventionally, a large increase in meteor showers did not show a significant increase in the number of detections. Therefore, I tried to find out the cause of such a thing and did this research.
It was hypothesized that natural factors such as topography and the output of HRO radio waves and VOR radio waves might be different.
The VOR radio waves we use are from Asahikawa Airport. The radio waves of HRO are from Fukui Industrial High School in Sabae City, Fukui Prefecture.
The results were not examined in detail for the output. In addition, we did not obtain well-founded concrete data on natural factors. Therefore, as a future subject, I would like to carry out a control experiment of Komatsu Airport VOR and HRO where the distance and direction can be aligned.

Keywords: meteor, Radio wave observation

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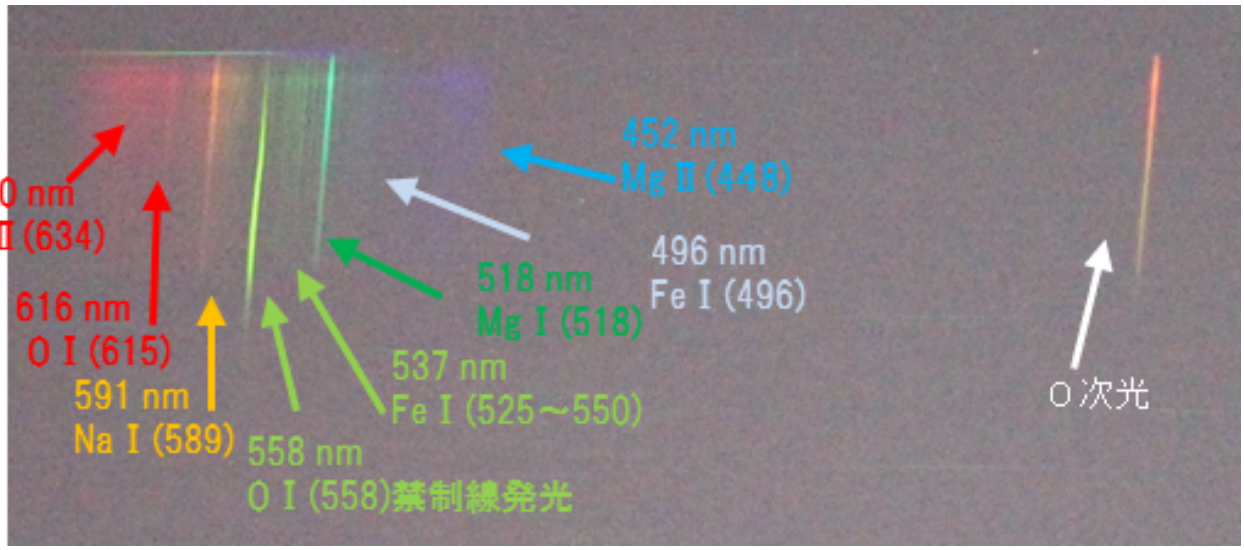
Spectroscopic observation of meteor using diffraction grating

*Soya Ito[1], *Atsuya Sugawara[1], *Tomoki Misao[1], *Shotaro Mino[1]

1. Miyagi Furukawa Reimei Junior and Senior High School

We do spectroscopic observations of meteors and identify the elements from which they emit.We attached the diffraction grating to the lens on the camera, and held the camera to shoot meteors vertically.When meteors are shot, we will do calibration to measure the scale of the diffraction grating spectrum.Then, the wavelength of the bright line on the image is obtained to specify the element derived from the light emission.Mostly sodium and magnesium were confirmed.

Keywords: Meteor, Diffraction grating



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Predicting the sea level change in the Ariake bay through analysis of diatoms and pollens

*Ayuto Yamashita[1], *Shino Furuta[1]

1. Kumamoto prefectural Amakusa High School

<Goal>
We set two goals for our study.
One goal is to research the sea level change in the Ariake bay in the past. The other goal is to predict the sea level rise in the Ariake bay in 50 years.

<Outline about the stratum>
We took 40 samples from the core bored in two spots, Aitsu and Amura, in every 10 cms. These two spots are both located in the mouth of the Ariake bay. We named the core in Aitsu “KZ”, and one in Amura “KM”. We found out the age of each layer of the core by radiocarbon rating and researching documentary records. It is shown in figure 1.

<Method>
In order to study the environment in the past, we analyzed diatoms and pollens in the samples. We draw diagrams after judging 200 fossil diatoms, and also 200 fossil pollens per sample, except pinus. Then, we calculated the temperature and precipitation in the past, using modern-analog method. We also investigated the data archaeologically with local historical records. Through these three processes, we learned about the paleo-environment of the land and sea. By examining how the environment has changed, we can clarify how it has affected our lives.

<Results>
The following is what we discovered through diatom analysis. We found a large amount of *Paralia sulcate* and *Cylotella Litoralis* in most samples. *Paralia sulcate* inhabits the seawater, which is known as an indicator species in bays. It is shown in figure 2. On the other hand, *Cylotella Litoralis*, inhabits the freshwater. *Tryblionella granulate,* which also inhabitants the brackish water, was found in all the samples. What we discovered through pollen analysis is as follows. Pollens of *Castanopsis sieboldii* and trees which belong to the *Quercoideae* family consist of as much as 80 –90 % of all pollens. It is shown in figure 3. The calculated temperature shifted between 16.0℃ and 17.4℃, and it rose 1.0℃ from KM-11 to KM-10. The precipitation changed between 1,800mm and 2,200mm.

<Considerations>
Analyzing pollens of the core bored in Amura, we assume there used to be broad-leaved evergreen forests there. The results we got with all the data we collected from the core and historical records are shown in figure 4. There are three assumable facts from this figure. The core of 7,700 –6,500 years ago contain the largest proportion of sea diatoms. It shows there was the Holocene glacial retreat in the *Jomon* period. Samples of 500 years ago contain small proportion of sea diatoms, and the temperature declined 0.7℃. It is because of little ice age then. In Amakusa, there was a period in which we had frequent heavy rains, floods, or droughts.

<The sea level change of Amakusa>
The observation of the sea level change of Amakusa. As mentioned before, we found *Tryblionella*

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granulate in diatoms of all samples, which is known as an autochthonous indicator species of tidal flats. According to Sato (2014), the spots which *Tryblionella granulate* were found indicate the sea level of the time they die and accumulate. In short, they can tell us how the sea level has changed. The estimated could sea level in Amakusa.

<The future prediction>
We found the sea level by focusing on *Tryblionella granulate.* Referring to the sea level *Tryblionella granulate* show, we found that the sea level rose 0.18cm a year on average during the period between 93 to 500 years ago. Thus, we assumed the sea level rose 2.5cm during the period of KM-7 to the top of the core, which means it took 14 years from the time KM-7 accumulated to the time of the boring. We learned that the temperature from the time of KM-7 to the top of the core was 0.011℃ on an average, since the temperature rose for 0.15℃ in that period. Therefore, it can be said the sea level rises 16.7cm/℃. According to the IPCC report in 2018, if the temperature rises 0.5℃ by 2030, it will be 0.042℃ hotter every year, and in 50 years, the temperature will rise 2.1℃ in total. Combining this IPCC forecast and 16.7cm/℃ sea level rise, it can be said that the sea level will rise 34.7cm in 50 years. If the temperature rises more moderately, 0.5℃ by 2052, it will be 0.015℃ hotter every year, and the temperature will rise 0.73. This will make the sea level 12.2cm higher. There are shown in figure 5.

<Conclusions>
Our study can be concluded in the following three points. First, we revealed how the environment in the Ariake Bay has changed since 7,700 years ago. Secondly, we calculated 0.7℃ decline of temperature during the little ice age in Amakusa. Lastly, we forecasted the sea level in 50 years will be 34 cm higher at most.

<Our future study>
In our future study, we are to calculate the area of the sandy beaches which can disappear because of the sea level rise. We also would like to calculate the sea level rise of other areas by discovering how to apply our results to the area at different latitudes.

Keywords: Sea level change, Diatom analysis, Pollen analysis

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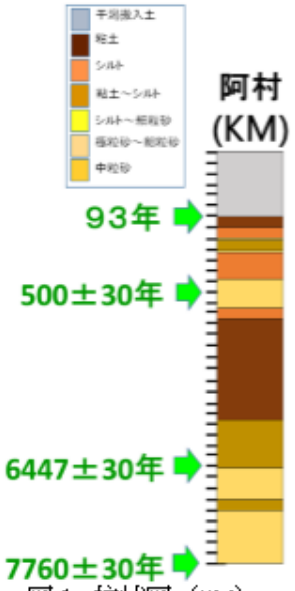


図１ 柱状図（KM）

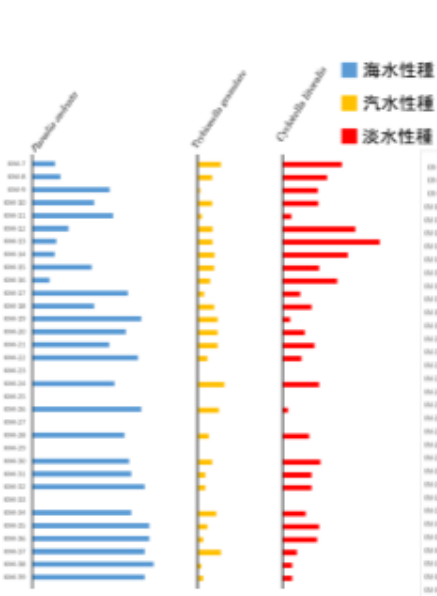


図２ 珪藻ダイアグラム（KM）

図３ 花粉ダイアグラム（KM）

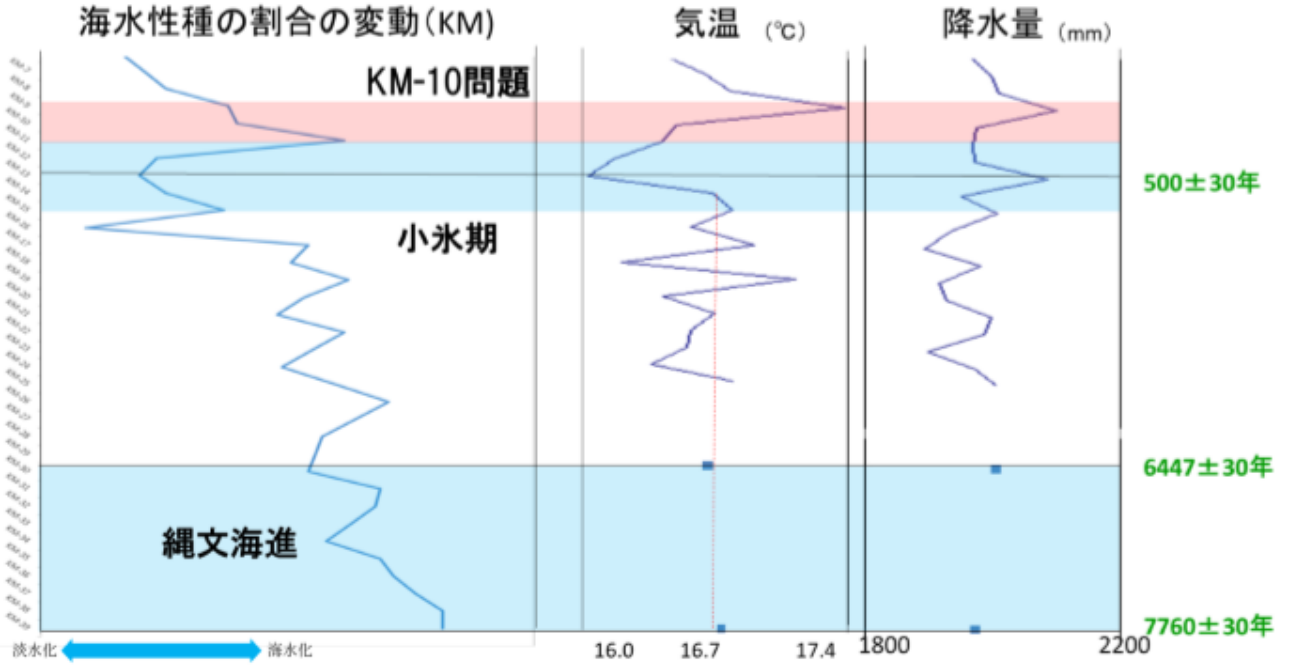
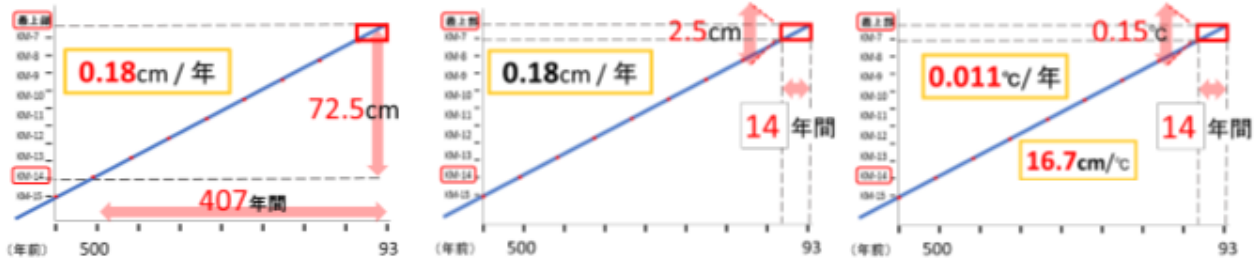


図４ 過去の環境変遷



	未来予測(50年後)	
	最大	最小
気温上昇速(℃/year)	0.042	0.015
気温(℃)	+2.1	+0.73
海水面(cm)	+34.7	+12.2

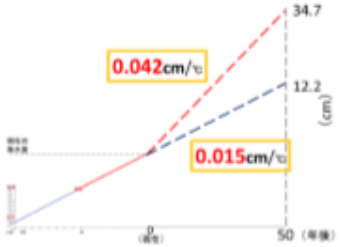


図５ 未来予測

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Altering unused irrigation ponds to mitigate flooding, maintain habitats, and reduce maintenance burden

*Rikuto Fukushima[1], Nao Maeda[1], Reo Yoneyama[1], Yuki Takahashi[1], Hiiro Tabata[1], Koutaro Hayashi[1]

1. Hyogo Prefectural Kakogawa Higashi High School

In recent years, many unused irrigation ponds have been reclaimed for building because of the difficulty in maintaining them and the decline in their use for agriculture. However irrigation ponds play an important role in not only agriculture but also flood prevention and maintaining ecosystem diversity. If irrigation ponds are reclaimed, these functions will be lost. In this research, we suggest a new maintenance method: low water level control. By keeping the water level in ponds low, we can better prevent flooding. Using this method, we can preserve the ecosystem. Also, we show that low water level control can be done automatically by using plugs on the bottom of irrigation ponds.

Keywords: irrigation pond, low water level control, flood prevention, ecosystem preservation

図１　源太池の位置

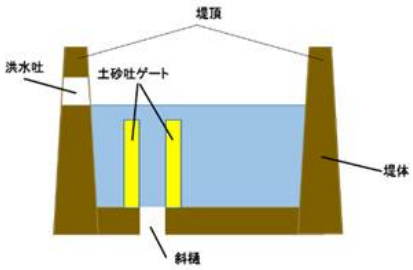

図２　ため池の構造

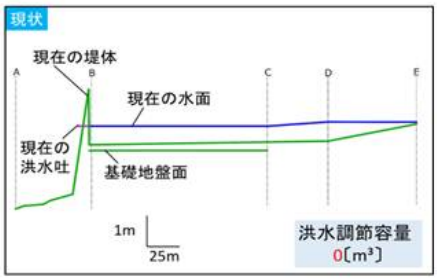

図３　源太池の現状の断面図

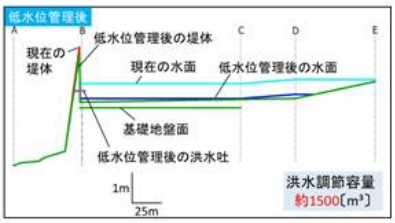

図４　源太池の低水位管理後の断面図

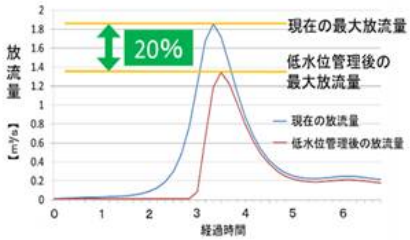

図５　低水位管理前後の
最大放流量の比較

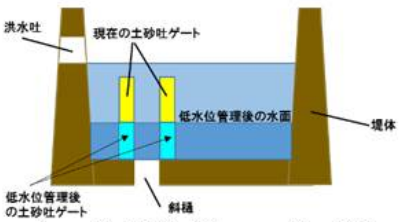

図６　低水位管理後のため池の構造

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Development of the equatorial telescope for from the beginners to the advanced astrophotographer at low cost

*Jun Ikeda[1], *Shimpei Iwasaki[1]

1. Kaijo Senior High School

We made an equatorial telescope to turn camera and telescope so that they will track stars. It’s necessary for astrophotography. The stepping motor which I can set rotational speed in detail and a gear with 120 teeth enable stable rotation of heavy equipment and precise tracking. In the future, we’re going to improve the structure, realize intuitive operation with a smart phone, simplify the task of alignment to the Polaris so anyone can make it and use it. Then we will write down the procedure and share on the Internet. We will also try various things and write them on the procedure as options because the greatest advantage of a self-made machine is that it’s possible to select desired functions.

Keywords: Equatorial telescope, Astrophotography, Telescope

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How ripples formation dependence on the size of sand grains and the amplitude of vibration cycle

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1. Kaijo Senior High School

How wave ripples can be formed? Using a plastic bottle which contains water and sand grains sorted by its size. We examined conditions by which wave ripples can be formed. We made a vibration apparatus using Lego Mindstorms to vibrate the plastic bottles horizontally and to control the amplitude and the period of the vibration. We count the number of tops of wave ripples each case and considered results.

Keywords: Ripple mark, Wave ripples , Sedimentology

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Organizing the relation ship of the viscosity of lava flow and the shape of columnar joijnt

*Kanta Takakura[1]

1. Kaijo junior and senior high school

Columnar joints are topography formed by causing volume contraction when the lava flow that has erupted and flowed from the volcano is cooled by the atmosphere.
It is known that the cross section of the column joint is basically hexagonal, but the actual column joints often take five or seven other than hexagons. We at Kaijo Chugakuji Faculty made an assumption that the cause of the irregular shape may be related to the viscosity of the lava flow, and tried to prove the hypothesis from the experiment. In addition, I thought that I could find the relationship between the nature of lava flow and the shape of the cross section.
In order to investigate the above things, once dissolving the starch in the water and then evaporating the water, the volume of the starch is shrunk to reproduce the "columnar joint" created in the same process as the process of forming the column joints. We did research by conducting experiments. Also, in order to reproduce the difference in viscosity of lava, experiments were conducted by changing the weight ratio of water and starch.

Keywords: Columnar joint, Volcano, Terrain

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Measurement of the geomagnetic horizontal component with a neodymium magnet

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1. Sapporo Nihon University Senior High School

In this study, we aimed to establish a new way to measure the earth’s magnetic field without external power sources. When a neodymium magnet suspended by a sewing thread oscillates freely, the oscillation period is determined using the value of geomagnetic horizontal component, inertia moment, and magnetic moment. We determined the magnetic moment on the neodymium magnet through two different methods and measured the oscillation period with a smartphone all over the world. The results showed that geomagnetic horizontal component was inverse proportional to the oscillation period squared, which agreed with the prediction from the formula which we established based on simple harmonic oscillation. We found that the geomagnetic horizontal component could be measured without external power sources, using a neodymium magnet that has already known magnetic moment. This method can be applied to measure the magnetic field in the cosmic space.

Keywords: earth’s magnetic field, neodymium magnet, magnetic moment

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Relationship between sun elevation and RGB values of sunlight color

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1. Sapporo Nihon University Senior High School

The color of sunlight can be quantified using RGB values and RGB values are known to change with the altitude of the sun. In this study, we aimed to investigate the relationship between solar altitude and RGB values in detail. The sun was photographed through a self-made light control plate with a 4-mm-diameter hole and the RGB values were analyzed using adobe photoshop, which is a bitmap image editing application software. The results showed that the ratio of R value increases and the ratio of B value decreases when the solar altitude is smaller than 9˚. We derived a theoretical formula that represents the relationship between the solar altitude and the thickness of the atmosphere through which sunlight passes. Assuming that the thickness of the earth's atmosphere is 100 km, the observation results and the theoretical formulas indicate that the thickness of the atmosphere through which sunlight passes is about 500 km when the solar altitude is 9˚. This means that when the thickness of the Earth's atmosphere is reduced to about 20 km, no red sunset will be observed all over the world.

Keywords: sunlight color, RGB value, sun elevation

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Reserch about Dokuzawa mineral spring on Shimouswa hot spring

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1. Naganoken Suwa Seiryo Senior High School

Only Dokuzawa mineral springs in Shimosuwa hot spring, Nagano prefecture, are strongly acidic, and there are doubts that there is a large difference in spring quality from weak alkaline hot springs in the same area, and it is hypothesized that the sources of both hot springs are different. We conducted surveys and measured oxygen and hydrogen stable isotope ratios.
From the geology and water quality survey near the Dokuzawa mineral spring, there are several locations where the pH is low due to water quality investigations, hydrothermally altered rocks, sulfur adhering to the surface are commonly seen, and at some points the odor of hydrogen sulfide is also confirmed did it. In addition, it was found from the geological map that the fault is underground. From this, it can be inferred that Dokuzawa mineral spring produced sulfuric acid by mixing volcanic gas with groundwater under high temperature and high pressure underground. In addition, from the measurement results of the isotope ratio, it turned out that the source of both hot springs is Rain water.

Keywords: Hot spring, Component analysis, Volcanic gas

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Can you predict the weaather when you see the starry sky

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1. Naganoken Suwa Seiryo Senior High School

1, Introduction

Water vapor has a major effect in astronomical observation. Using that fact as an underhanded way, I thought that it was possible to predict the weather in the end by estimating the amount of water vapor in the sky according to the appearance (brightness) of the stars.

2, trial of observation

In the initial observation, I tried to measure the brightness of the star by the naked eye, but I thought that an error would occur, and improved it so that the brightness can be compared objectively by adjusting the brightness with the iPhone camera app.

3, result, summary

From the observation results this time, it has been confirmed that water vapor interferes with star observation.

We will continue to observe whether it is caused by differences in altitude, environment or season, compare it with meteorological observation data, and look for the cause of the difference in the appearance of stars.
In addition, there is a part where the appearance of stars clearly appears, so I would like to find out the cause other than the difference in elevation such as the difference with other points.

Keywords: weather, star, water vapor

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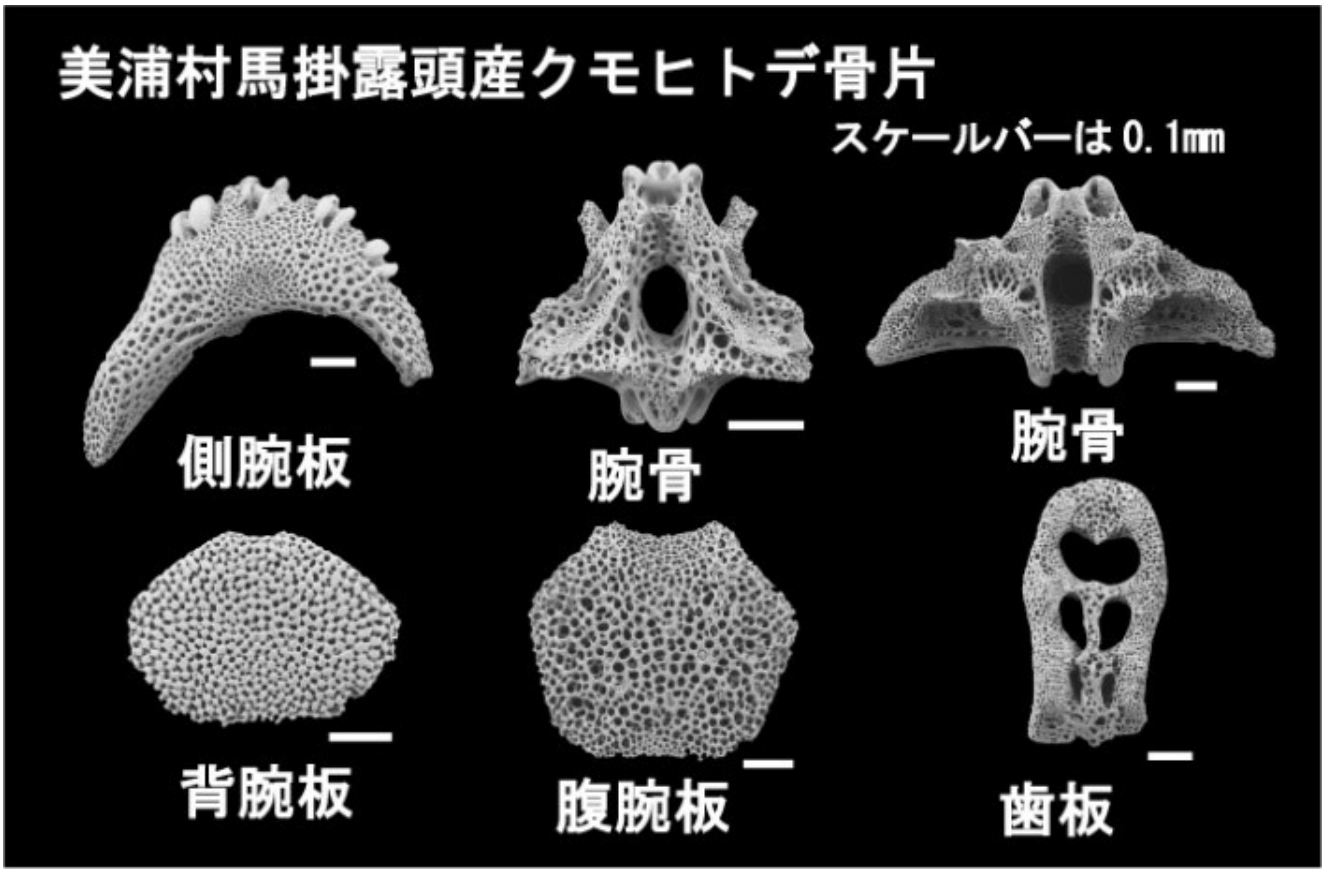
Fossil ophiuroid ossicles and ostracods from the Shimousa Group distributed around Magaki, Mihomura, Ibaraki Prefecture

*Asaka Yokobori[1], *Rin Mita[1]

1. Gunma Prefectural Ota Girls' High School

We have collected four sediment samples from the Shimousa group distributed around Magaki, Miho-mura, Ibaraki Prefecture. The depositional environment of the Shimousa Group at the study site was inner to middle bay area from the analysis of the ostracods fossils. In addition, in the process of processing, it was possible to pick out the fossils of ophiuroids ossicles. These fossils of ophiuroids ossicles were found to be part of the fragments that make the arm of the ophiuroids, the vertebraes and the lateral arm plates. These could be identified in the family Amphiuridae. The identification of this fossil ossicles genus and species is further study. Show the fossils of ophiuroids ossicles in the figure.

Keywords: stracode, fossil ophiuroid ossicles, microfossils, Magaki, Shimousa Group



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Conservation activities for bivalve fossils by Muroto High School Students

*Shuka Ishitani[1], Miku Ōno[1], Fukuoka Eri[1]

1. Muroto High School

Miocene deep-sea bivalve fossils are located at the coast of Muroto UNESCO Global Geopark (Muroto City, Kochi Prefecture). These are the one of the pieces of evidences of repeated uplifts of the land of Muroto. Although most parts of the coast of the city are designated as a quasi-national park and protected by the natural park law, we do not have the way to protect the fossils themselves. Therefore, we (high school students) submitted an application to the city, requesting these fossils be designated a City Natural Monument, in an attempt to get them widely known. We explain the significance of the conservation of the deep-sea bivalve fossils and our activities in this presentation.

Keywords: fossil, natural monument, Muroto UNESCO Global Geopark

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Changes in Shinto Festivals in Muroto UNESCO Global Geopark

*Eri Fukuoka[1], Nanami Hashimoto[1], Yui Takemura[1], Hayato Nii[1], Taisei Hamada[1]

1. Muroto High School

We studied the current state of the traditional festival (Shinto festival) in Muroto UNESCO Global Geopark (Muroto City, Kochi Prefecture), in order to discuss what high school students can do in the age of declining birthrate. Each settlement in Muroto has traditional festivals and events. The festival in Ukitsu area, central Muroto, is held every October (October 6-7, 2018). Ukitsu area once flourished with whaling. Several ceremonies that originated from old-style whaling take place at the festival. The style of festival has been transformed to reflect changes in society. Population decline may make it difficult to inherit traditions. We, the young generation, need to cooperate with the adults, actively participate in the festival, and take over the tradition. We would like to call on the outside for participation.

Keywords: Shinto Festival, decreasing birthrate, Muroto UNESCO Global Geopark

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The Study of Old Tottori sand dunes. Why the sand become hard ? Epilogue

*katsuki takana[1], *ren osaki[1], *ritsuki sugiura[1], satosi arita[1], syogo okayama[1], yuta sunaba[1], aoi hashikawa[1], ken hirooka[1]

1. Tottori Prefectural Tottorihigashi High School

Tottori is famous for the Tottori sand dunes. Statues of sand are netter formed by water and sand. But, when we make a statue of sand, old sand is more to fix a statue than new sand. As a result, there are various sizes of sand and it fill space with clay minerals. Clay minerals help to combine old sand with each other. The secret of sand is enjoyable to learn about.

Keywords: geology, lithology, micromeritics

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Forest education by the making of a clay ball and a moss ball

*Yuna Miyachi[1], Arika Tsuji[1], Yuzuki Kobayashi[1], Sae Takami[1], Tatsuki Morikawa[1], Ryota Yamasaki[1], Yuto Umeda[1], Matsuki Rina[1], Nahoko Kubo[1], Yo Sayama[1]

1. Kyoto Prefectural Sagano High Scool

Recently, through direct experience, we learned about forests, which are the natural environment in our local region that fosters the recycling of resources, the cultivation of technologies, and attitudes related towards forests. These attitudes include sensibility, sociability, problem solving power, etc., and form our society and future education aimed at human resource education that will promote a sustainable social culture. In this study, we examined the making of clay balls and moss balls for forest education purposes. The purpose of our study was to study how to make the shine of the clay ball more easily and to clarify the conditions under which long-term nurturing was possible. One of the reasons why clay balls “glow” is explained by the orientation of the soil particles, and that tendency is strengthened by polishing. Although various materials were examined in this research, we were not able to make the ball shine when the soil particle shape or size was too small. Further study will be necessary in the future. For the moss ball, it is generally said that it is difficult to nurture moss balls indoors. Therefore, in this study, it was considered necessary to study the nutrient source of the moss in order to enjoy it for a long time. Regarding the health of moss, color changes when pure water and rainwater were given to the moss was compared using RGB values. As a result of using three types of moss from various sized communities, it was found that moss given pure water changed color in a relatively short time. From this, it can be inferred that there is a component contained in the rain water causes the moss to last longer, and it has been found that it is necessary to supply a certain amount of rainwater as a nutrient source.

Keywords: Moss, Forestry, Clay

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The Roles of Clay Minerals in the Pedosphere of the Woods for Field Practice Owned by Sagano High School

*Nahoko Kubo[1], Yo Sayama[1], Yuna Miyachi[1], Arika Tsuji[1], Sae Takami[1], Yuzuki Kobayashi[1], Yuto Umeda[1], Tarsuki Morikawa[1], Ryota Yamasaki[1], Rina Matsuki[1]

1. Kyoto Prefectural Sagano High School

Soil is in the central feature of the forest ecosystem. Clay minerals which are one of the component positions of forest soils the soil have certain some characteristics. For example, they have a large specific surface area, and have a negative net charge, characteristic, are a source of supply of the nourishment for the plants, and have a high water holding capacity ability from like the adsorbed water and pore spaces for water. There are many kinds of clay minerals have many kinds and each one has characteristics of that greatly different. From the research by Okubo (2015), the clay minerals called Lepidocrocite that are involved in the characteristic reddish layer of soils were confirmed within the soil profile in the WFS. In this research study, we analyzed the clay minerals of the soil profile by using X-ray diffraction in a spot is different from the prior research. We revealed the role of clay minerals from the point of view of pedogenesis. As a result of X-ray diffraction, Vermiculite, Mica, Kaolinite, Gibbsite, Quartz, and Hydroxyl interlayered vermiculite were confirmed to be present. And from the examination of the soil profile, we confirmed a reddish layer but did not confirmed Lepidocrocite because of the difference in tree species and topography. For our next steps, we will compare Now, I am comparing weighing the data gathered by of Okubo(2015) and Matsuki (2019) against this study’ s data research’ s one.

Keywords: Clay Minerals, Soil, Forestry

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For the development of brand-name products in WFS. ~ Selection of high quality Chamaecyparis and investigation of suitable drying method ~

*Yuzuki Kobayashi[1], Sae Takami[1], Rina Matsuki[1], Ryota Yamazaki[1], Yuto Umeda[1], Tatsuki Morikawa[1], Nahoko Kubo[1], Yo Sayama[1], Arika Tsuji[1], Yuna Miyachi[1]

1. Kyoto Prefectural Sagano High School

Trees in the Woods for Field Practice Owned by Sagano High School (WFS) woods for fieldwork owned by Sagano high school have been left untouched after they were planted about 65 years ago. Therefore, we decided to work on product development using materials. When we carefully process use timber whose pith is in the center, warping or cracking decreases during while in the drying process, and we can use beautiful quarter-sawn timber. In our research, we studied about the method of estimating the tree pith and the process of drying wood. We obtained I got the core samples from of six trees with various chest height diameters using an increment bore to estimate the pith without cutting down the trees. However, it was difficult to pierce the pith of the trees accurately. When we regarded the center of tree profile and tree pith, the form of the tree profiler received a natural impact and a human impact. Disagreement of the position tree pith and center of tree profile occur. Therefore it was extremely difficult to pierce the pith of the tree using the increment bore. We will next try to simplify the form of the tree rings and calculated the position of the pith of the trees mathematically now. On the other hand, is to last a long time and not to be broken. In our research, we evaluated the efficacy of the drying methods between of natural drying and natural drying after the exudation of sap. The items under examination we are the time required to dry, and understanding the conditions of warping and cracking after drying. We measured the mass and the volume of Cypress (*Chamaecyparis obtuse*) which we brought from WFS. We and I dried it all in four places on campus.

Keywords: Forestry, Chamaecyparis

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Grasping the human impact following a forest research and its recovery

*Yo Sayama[1], Yuna Miyachi[1], Arika Tsuji[1], Sae Takami[1], Yuzuki Kobayashi[1], Yuto Umeda[1], Tatsuki Morikawa[1], Ryota Yamasaki[1], Rina Matsuki[1], Nahoko Kubo[1]

1. Kyoto Prefectural Sagano High School

We have researched the forest environment using field surveys covering a five year span in the Woods for Field Practice Owned by Sagano High School (WFS). We discovered that pathways had become bare or were eroded. In this research study, we aimed to evaluate the change in the influences on the environment that the investigative actions have had on the WFS by our maintenance of walkways which we can make easily and use continuously during our fieldwork.

Therefore, we established three areas within the WFS and experimentally studied the gravel which is the natural groundcover material. We spread black rock that had a diameter from 3 to 4cm in the areas where the high school students usually go within the WFS. Then we waited while many researchers walked back and forth across the span where we left the rocks. After that time, we determined the proportion of gravel which remained in the areas and was not disturbed by all of the foot traffic. There were three defined zones within our area of study. The incline of area 1 is 4˚, area 2 is 27˚, and area 3 is 16˚. As a result, we found that the proportion of gravel which remained was 93% in area 1, 43% in area 2, and 75% in area 3. After the experiment, in area 2, the gravel was buried in the ground and it has been suggested that this area should be made available as the permanent walkway. From this study in the large-incline area, we have learned that we may need to spread the gravel out more until it is buried in the ground. However, carrying the gravel is too much work to maintain it easily in the future. We think that while it would be good in practice, it is an unrealistic goal. We will examine spreading the gravel with timber. Furthermore, we will guide people by using a guide rope. This was confirmed to be an effective method from two teachers who are experienced mountain climbers.

Keywords: Forestry, Soil Erosion, Human Impact

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Considering the recent landslide disasters in Japan -Movement of water in pedosphere-

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1. Kyoto Prefectural Sagano High School

The importance and function of retaining water in that forests has been clearly stated in studies before said, and landslides are still occuring have continued to report. In researches performed by our school, the decreasing in understory vegetation by deer (Cervidae) was reported, and the water holding property of the soil was be decreased because of the possibility decrease of evapotranspiration and soil erosion. It means that rainwater reaches the rock layer directory and this condition cause will cause landslides. In this research study, We performed a soil profile, a soil three-phase distribution and a soil permeability investigation to measure the state of soil especially the water retention capacity within on the soil of the Woods for Field Practice Owned by Sagano High School (WFS). As a result of this soil profile, the WFS was found to have (the Woods for Field Practice Owned by Sagano H.S.) has Japanese general soil and the pedosphere was up is to 60 cm in depth. And the WFS’ s soil has a reasonable water retention capacity for plants. On the other hand, soil permeability was relatively good. It means that water will reach the rock layer when it have rains beyond the fixed quantity.

Keywords: Forestry, Landslide Disasters, Soil

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Comparison of GSI map data with the surveying data by targeting Woods for Field Practice Owned by Sagano High School

Yuto Umeda[1], Tatsuki Morikawa[1], Ryota Yamasaki[1], Rina Matsuki[1], Nahoko Kubo[1], Yo Sayama[1], Yuna Miyachi[1], *Arika Tsuji[1], Sae Takami[1], Yuzuki Kobayashi[1]

1. Kyoto Prefectural Sagano High School

We have performed over 50 research activities in the W.F.S. and researched about them. However, we have not analyzed rearranged all of the data yet. In this study, we wanted aimed to clarify how precise the Geographical Survey Institute (GSI). GSI map data of the area actually was, assuming that our surveying data of W.F.S was more accurate than altitude data available on GSI on GSI maps. We conducted a plane surveying and gathered all the latitude, longitude, and altitude data. Using this data, we ran a process within the GSI system were able to process them. Also, we created 3D models using a 3D printer. As a result, we confirmed that the surveying model was more accurate than the available GSIGSI map data. When we tried to create the model in three dimensions with the printer, we reviewed appropriate methods and considered which resin would be better to use. We modeled the wider area based on the GISGSI map mainly because there was a request from nearby local elementary school that requested a vast area model, but in the future it is anticipated that we could utilize the model for various research activities in the W.F.S. By using the large 3D model, we may be able to do many experiments such as research sediment disasters.

Keywords: GSI, Forestry, 3D Printer

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Summary of our activities and the future direction in the Woods for Field Practice Owned by Sagano High School

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1. Kyoto Prefectural Sagano High School

The purpose of this thesis is to summarize our research activities in the Woods for Field Practice Owned by Sagano High School (WFS) which is a forest in which more than 80 students have conducted research within over a 5-year span. We wanted to propose a future direction for the WFS. The location of the WFS is recognized as a “Local Forest Area”, which means a place that borders an urban area and a mountainous district. Since Japanese cedar and Japanese cypress were planted there around 70 years ago, proper forest management has not been conducted there at all. We have surveyed about half of the 1.9 ha WFS area and processed this data in Geographic Information System (GIS) software. Although the slant is 20 to 40 degrees, there is no clear soil outflow classified as “Moderately Moist Brown Forest Soil”. On the other hand, harmful animal damage by deer (*Cervus nippon*) is remarkable, and so we are concerned if, for example, soil erosion occurs due to a decline in understory vegetation. We cannot expect the soil to be a soil seed bank because the pH level of the soil is low and the germination inhibition effect is strong. According to aerial image videos taken by drone, we found the canopy was extremely dense and it is urgently necessary to thin the forest. From the viewpoint of recent landslide disasters within forests, we conducted research on both the soil profile and the soil permeability. As a result, it turned out that the soil can hold rainfall to a certain level. We considered, however, that landslide disasters are likely to happen in the case of heavy rain because the soil permeability is relatively high and the rain passes through the soil (or the pedosphere) and reaches to the lithosphere. In the future, we will approach our research from the viewpoints of both hydrology and forest information analysis in the WFS.

Keywords: Forestry, Soil

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Our challenge, the frozen earth : soil formation under the maple forests in Quebec

Yo Sayama[1], Rina Matsuki[1], Yuzuki Kobayashi[1], *Sae Takami[1], Nahoko Kubo[1]

1. Kyoto Prefectural Sagano High School

In this research study, we wanted to establish the pedogenesis in a Maple artificial plantation which is one type of the representative forest vegetation in Quebec, Canada. The investigation spots included two locations are two, and the survey items included are a soil profile investigation, soil crackle strength, soil temperature, soil pH, soil EC, soil respiration, and a crown observation. We had 30-40 cm of the snow of 30 - 40 cm on the investigation day in (the end of March,) and we confirmed a freeze state in the LFH layer and the upper part of the A layer of the soil. However, in places deeper than the lower part of the A layer was in a drying state and we did not confirm a freeze state there. It was revealed that the soil was softer than typical the general Japanese forest soil in both investigations by using with boring stick and a Hasegawa-type soil penetrometer. Next, we perform a comparison to Japanese soils with the general Canadian forest soil.

Keywords: Canada, Soil, Forestry

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Color of the moon at the umbra lunar eclipse

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1. Saitama Prefectural Urawa High School

It is well known that the moon in the lunar eclipse is not dark and looks reddish. Because the area around the edge of umbra appears in blue in the photo, it is called "turquoise fringe". However, this effect may have been emphasized by image processing. Then, we conducted spectrum observation and found that the color of umbra doesn’ t verge on turquoise but white.

Keywords: Umbra lunar eclipse, Turquoise fringe

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Study on vegetation change and validity of eruption age based on pollen analysis of the strata containing volcanic ash

*Taiga Suzuki[1], *Haruki Otiai[1], *Keita Ueno[1], *Athushi Watanabe[1]

1. Nirayama HighSchool

I Research Overview

There are many studies that lead to the reconstruction of the paleoenvironment of the Izu Peninsula. We focused on volcanic ash, which is abundant in the stratum.

The strata of Izu Peninsula are composed of strata such as loam and various volcanic ash layers.

Since the age of the volcanic ash layer is already known, we can know the age of the adjacent loam layer. Since the loam layer contains pollen fossils of plants that were inhabited at that time, the proportion of pollen by type reflects the vegetation at that time. Therefore, we can estimate the vegetation at that time by pollen survey. By combining strata age and vegetation data, we are able to estimate vegetation transition and climate change. In addition, the validity of the eruption age of volcanoes can be confirmed.

II Research method

We sampled the loam according to the depth from one stratum, and estimate the age from a neighboring volcanic ash layer. Next, we extractd pollens from each sample using pollen extraction method. And we identified the species of the extracted pollen, counted it by type, calculated the ratio, and use it as the data of the vegetation at that time. Finally, based on these data, we tried to consider the appropriateness of the vegetation transition, climate change, and eruption age at that time.

III result

The mainly observed pollens were Sudajii, Pussy Willow and Ginkgo.

Sudajii is a plant distributed south of Niigata-Fukushima, which has disappeared since the eruption 125 thousand years ago, but has been revived since the eruption 103 thousand years ago.

Pussy willow is distributed in Hokkaido-Kyushu, and its habitat was confirmed in all plots.

Ginkgo inhabits in the range of annual average temperature 0-20 ˚C, and did not inhabit at first, but it appeared from 124 thousand years and increased.

VI consideration

Based on the we ratio fluctuation, we considered that the temperature dropped as cold as the Tohoku northern part or as the southern part of Hokkaido since the eruption of 125 thousand years ago, and rose around the 103 thousand years ago. This consideration was also consistent with the temperature variation data derived from the Antarctic ice sheet analysis.

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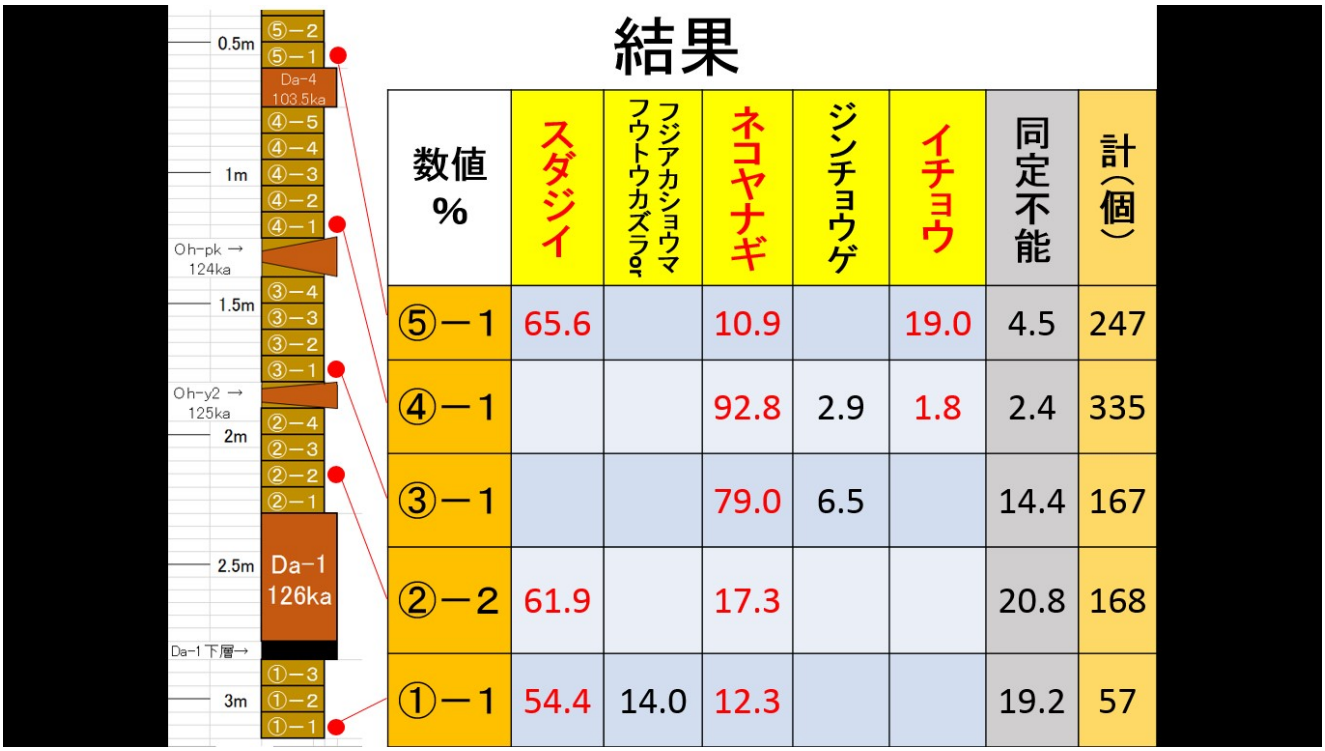
We are currently analyzing the entire samples to investigate temperature changes in detail. At that time, in order to reduce individual differences in judgment in pollen, we aligined the judgment criteria firmly.

Keywords: Volcanic Ash, Pollen



結果

数値 %	スダジイ	フジアカショウマ フウトウカズラ?	ネコヤナギ	ジンチョウゲ	イチョウ	同定不能	計（個）
⑤−1	65.6		10.9		19.0	4.5	247
④−1			92.8	2.9	1.8	2.4	335
③−1			79.0	6.5		14.4	167
②−2	61.9		17.3			20.8	168
①−1	54.4	14.0	12.3			19.2	57

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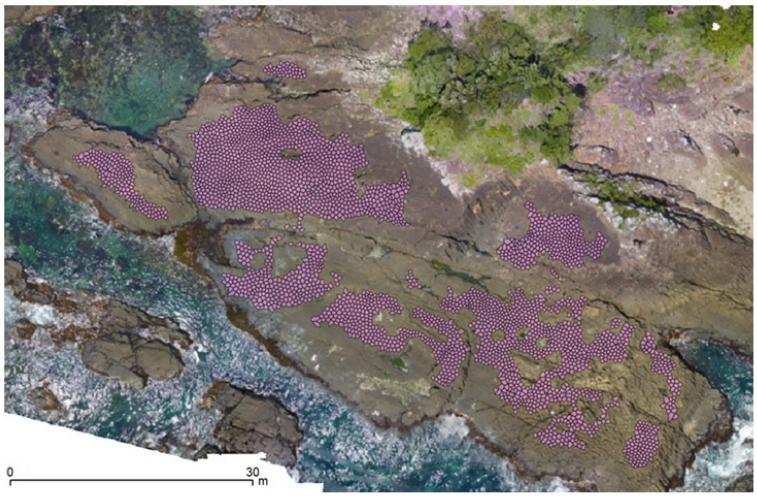
Statistical analysis of the columnar joints shape and study of its formation factor using high resolution 3D model by multicopter photos

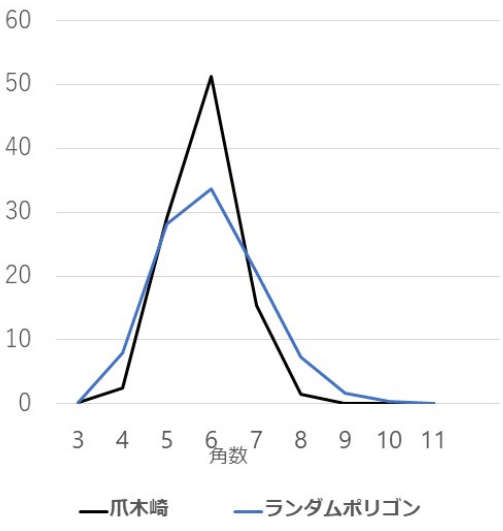
*Akihito Oota[1], *Kouta Enomoto[1], *Maho Kubota[1], *Minako Nishijima[1], *Atsushi Watanabe[1]

1. Nirayama HighSchool

By the drone, we took the aerial photograph of the columnar joints outcropped on the coast of Tsumekizaki in Shimoda city, Izu Peninsula, and analyzed the statistical distribution of the columnar joint forms. In addition, we analyzed the varying factors by columnar joint using starch experiment and by the columnar joint simulation based on random points as contraction centers. According to the data of Tsumekizaki, the number of hexagons is the largest, followed by the number of pentagons and heptagons. the starch experiment, the number of hexagon was the largest, and the distribution was such that there were more pentagon and heptagons than the distribution of the columnar joints of Tsumekizaki. The columnar joints with random points were distributed from triangle to hendecagon, and had the less hexagons than that of Tumekizaki. In the ideal cooling, which is a case where the columnar joints were based on the contraction centers arranged at equal intervals, it becomes all hexagons. But, in the case of the random point columnar joints, the shapes other than hexagon increase. Accordingly, it is considered that the form variation of the columnar joint is related to the heterogeneity of cooling.

Keywords: columnar joints





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Restoration of the Paleo-Kano Bay

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1. Nirayama HighSchool

I. Background of research

In the Tagata Plain in the northern part of the Izu Peninsula, the sea called "Old Kano Bay" was spread by the Jomon Transgression. There have been studies to restore its coastline, but we have done research to improve its accuracy. Although it is customary to restore the coastline from the results of the topography and boring investigations, we tried to restore the distribution of the ruins and the distribution of *Quercus. Phillyraeoides* (Ubamegasi).

In the preceding studies, they tried to distinguish the land stratification and the sea stratification, and to identify its coastline using the method of measuring the sulfur concentration of the soil, the method of examining the pieces of diatom and the electrical conductivity of soils.

In the Kanto Plain, which concentrated on the damage caused by the Kanto earthquake was similar to Tagata Plain in the terms of that it was the sea and the week ground. Therefore, it is possible to predict the existence of the weak ground in the underground several tens of meters by restoring the coastline at that time, it can be expected to be useful for disaster reduction.

Ⅱ. Research Theme

1.Restoration from ruins

We distribution of the ruins from the Jomon period to the Yayoi period and summarized it on a map.As the age progresses, it moves from the mountains to the plains. The important thing is that in the Jomon period, where the plains which had been the sea has no ruins, and the distribution moved to the plains when the resigning happened. It is presumed that Tagata Plain is a non-residential area in the Jomon period.

2. Restoration from *Q. phillyraeoides*

(1) Distribution Survey

Q. phillyraeoides is the weak plant in the flatland survival competition and prefer the rocky coastline. But the inland part of Tgata Plain, there is a place where *Q. phillyraeoides* colonies exist. So, we supposed that the *Q. phillyraeoides* which exist in the inland, advanced the inland when the Jomon Transregression happenedInland, and was stranded after resigining.

Fieldwork is conducted in Tagata Plain and the west coast of the Izu Peninsula. We picked 12 new samples in the inland area, and 27 new samples in the coastal area. Almost all inland, *Q. phillyraeoides* are similar to the coastal areas of the plant like cliffs and rocky habitat which is difficult environment to exist.

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(2) **DNA Survey**

We assumed coastal colony have been isolated more than 6000 years. It could have caused some differences between DNA of both. To find the changes, we compared DNA of inland and those of coastal area. And tried to prove inland *Q. phillyraeoides* were left behind by the Jomon transgression. Frozen powdery sample DNeasy Plant Kits by DNA of extraction and try to amplify DNA by PCR

We used *Matk,* the *trnH-psbA* and the *atpB-rbcL* as primer. After the amplification we performed Electrophoresis and compared DNA by result of it. We couldn’ t put the band in a sample of all. But, it seems to be differing slightly between Moriyama in inland and Usibuseyama in coastal area. However, samples concentration is very small. we could not do comparison with other samples and reproduction of experiment. we do experiments, changing the DNA extraction Kit. we used Lysis Solution SLS for Six samples (kareno Park, suisyou Mountain, Siroyama-do, Koganezaki, nannzou, Nagahama castle), and extracted DNA. We do these samples confirmation experiment of DNA.

As a results in all of the samples DNA of a band indicates the presence.

DNA of failed to amplify all but succeeded in extracting the. Conceivable as a cause is concentration and turbidity of impurities. But there were some differences in DNA. Future tasks are further gene analysis such as nucleotide sequence and examine the conditions of PCR.

III Conclusion

Now that we have been able to find many *Q. phillyraeoides* colonies, we can estimate coastlines more finely. In previous researches, it was estimated that the area near Siroyamado would be the southern end, but because there are many *Q. phillyraeoides* living in the south of Siroyamado, the southern end of Kokano Bay is estimated near the Mt.Suisyozan or south of Mt.Suisyozan in this study . Also, from the previous research and this research result, it is considered that the coastline will be as shown in the figure.

IV References

Genetic variation and structure of *Q. phillyraeoides*, In Japan revealed by chloroplast DNA and nuclear microsatellite markers

V Acknowledgments

Mr.Yusuke Suzuki, Deputy Secretary-General, Izu Peninsula Geopark Promotion Council Secretariat, for his great cooperation. Thank you very much to National Institute of Genetics Mr. Ken Kurokawa, Mr. Ryo Toyoda.

Keywords: Ubame Oak, Jomon period

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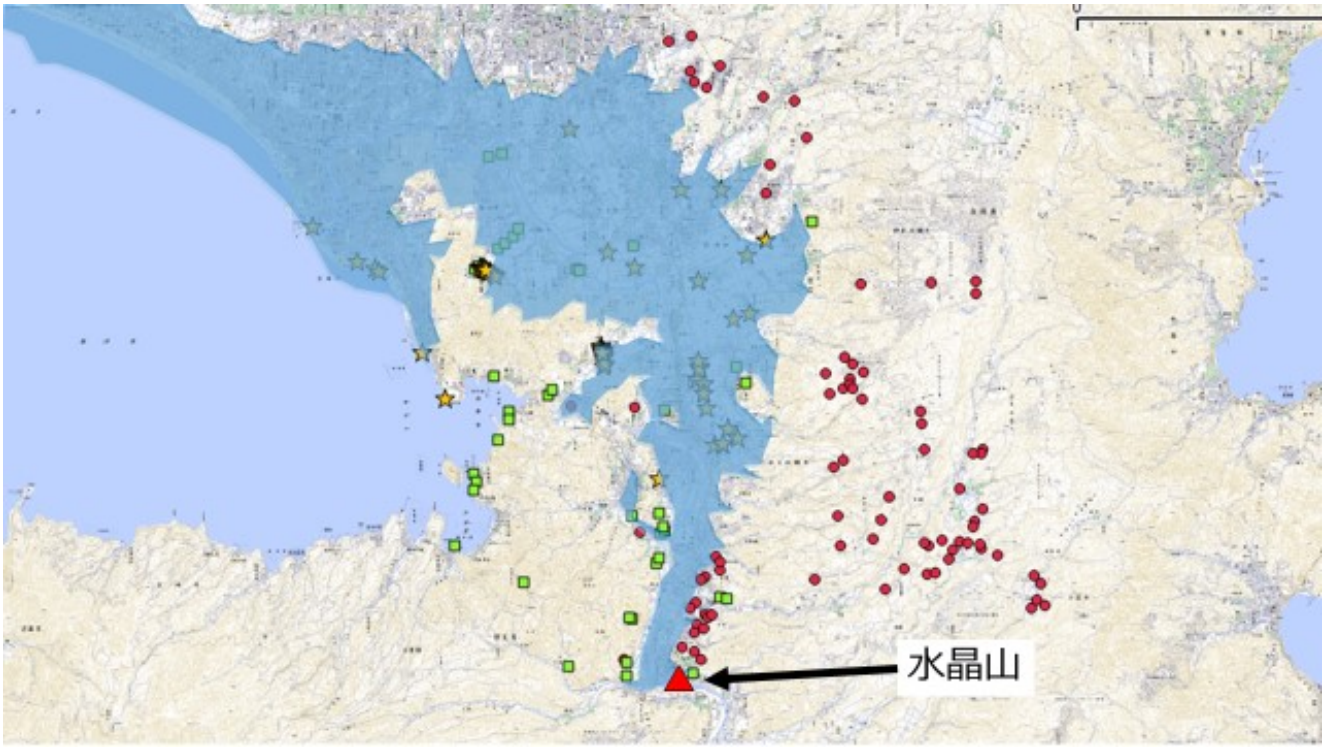

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From deep water circulation to the World's environment

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Professor Hibiya Toshiyuki, from the Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, reports on thermohaline circulation which is a part of the deep sea circulation transporting heat from surface layers to the deep.
This makes a livable environment for us, and it is affected by tidal water flow from the moon.
Tidal flow effects the seamount at the bottom of the sea, and turbulent water flow occurs in the oceans.
For four years, we have confirmed whether the process which causes the tidal current is caused by this moon is correct or not, so we focused on the turbulence generated in the ocean by the tidal current.
We modelled seamounts and the sea using plastic plates, gypsum, heaters, high-speed response temperature probes, ornamental aquariums, ice, salt, ink, and flushing to analyze temperature changes and visible flows, which I have been experimenting with.

Keywords: sea

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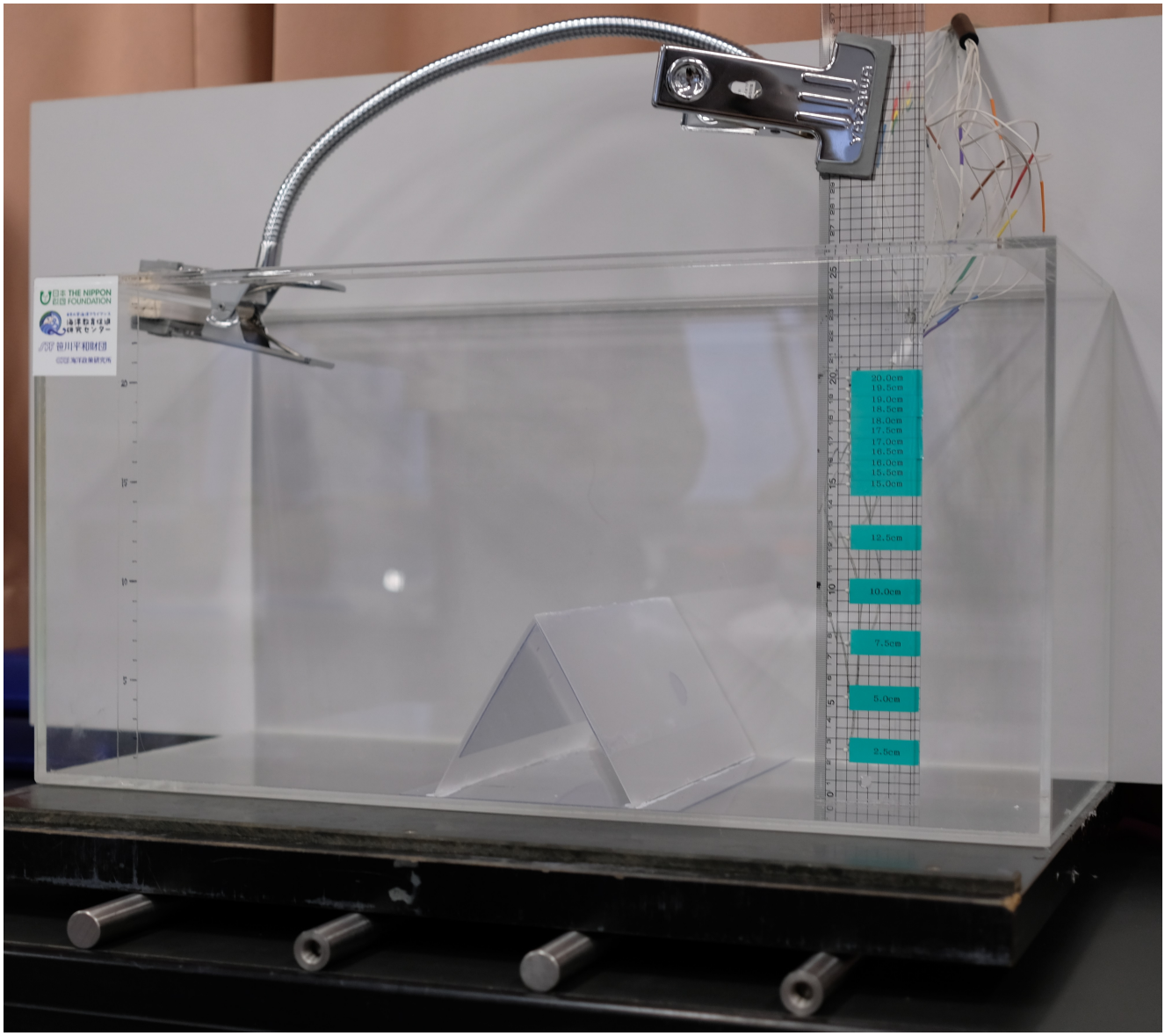

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Mystery of hot and cold Hatoyama

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Hatoyama, a town placed on center of Saitama prefecture, has an inland climate, and it has a unique feature:

Hot in summer season, but also cold in winter season.

Recent years, it is often observed a lot in winter that the minimum temperature of Hatoyama is colder than Chichibu’ s one; a town on basin, which means a flat area, and high altitude.

We tried to solve this mystery by investigating the data from Amedas, experiments in topographic models, and measurements of temperature in reproduced state of different land uses.

Keywords: air temperature, land use, radiative cooling

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A New Story for Saturn Satellite Dione's History seen in Crater Counting

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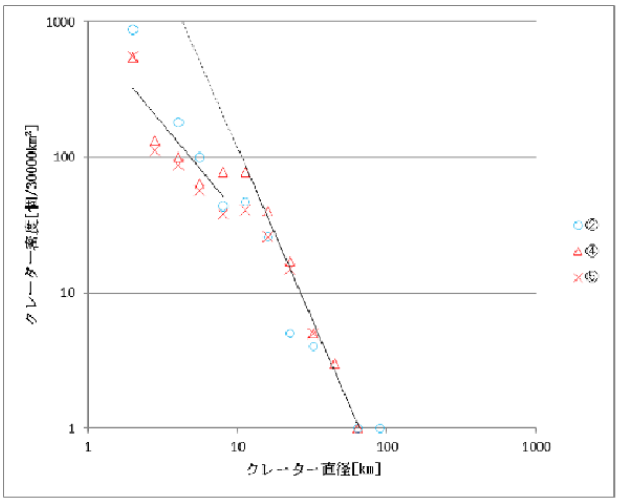
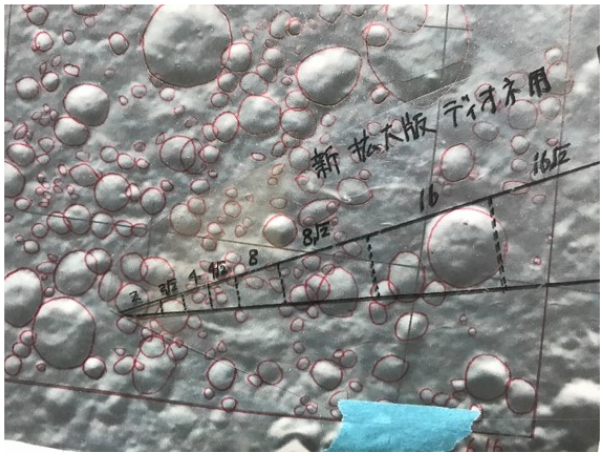
The rotation and revolution period of Saturn’ s satellite Dione are synchronized. In this case, we assume (Area with many craters) = (Area where meteorite is likely to hit).

Meteorites are generally likely to hit the leading hemisphere of the satellite (Hirata 2016), however, from the whole image of Dione, the crater distribution on the trailing hemisphere seems to be more concentrated than on the leading hemisphere. We tried to make a new explanation for the surface history of Dione with our detailed crater counting.

Keywords: crater counting, icy satellite





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Which Weather Proverbs are Suitable for The Weather Forecast in Osaka

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These days, weather is forecasted by supercomputers, but people in the old days anticipated the weather using the weather proverbs. We think that in the present age where climate change is occurring, the success rate is low. In this research, we observe and record the shape of clouds and changes in weather at school and calculate the success rate with the data measured by the Japan Meteorological Agency. From the result, we will select a highly desirable weather proverbs those are suitable for present Osaka.

Keywords: Meteorology

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An Effect on Seismic Waves Beneath Active Volcanoes

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In this study, we would like to reveal ' ‘What is the influence of seismic waves passing thorough magma" There are two kinds of seismic waves, P-wave and S-wave. P-wave can pass through solid, liquid and gas, however S-wave can only travel through solid. So, if the seismic waves pass a liquid magma, their waveform should become unclear. Unclear waveform means that the distinction between P-wave and S-wave become unclear. There are various ways to estimate the existence of magma, however it still be uncertain. We try to find an evidence of magma using seismic wave analysis.

Keywords: Eaerthquake, Volcano

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The Research Analyzes Structure of Ray with Crater

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1.Research Object

Ray is saw on the moon. It is a redial pattern of lines. We knew how to repeat example to make meteorite familial based the meteorite theory, and we thought repeat example is make ray too. This research, we used these way, and we researched to make ray in a variety of situations in moon.

2.Research Method

In our experiments, we used starch and baby powder as moon surface and falling meteorite. We chose these powders in consideration of scale effect.

We dropped in models of meteorite from the same height to calculate physical energy. Meteorite models were made by powder with two measuring spoons.

We try three patterns of experiments.

1. when we drop starch balls on the floor

1, Starch balls which were supposed to be falling meteorite models were made with two measuring spoons.

2,This balls are dropped on the floor from height of 25cm,50cm,75cm,100cm.We did this experiences five time a height.

3,Spreads of starch were recorded.

2. when we drop starch balls on the starch floor

1, Blue-colored starch and red-colored starch were made by using food coloring.

2,Red starch balls which were supposed to be falling meteorite models were made with two hemisphere spoons.

3,Blue-colored starch, which was supposed to be moon surface, was laid over a white sheet. The range of spread starch is four times as the radius of the balls.

4,The balls were dropped on the starch floor and recorded spreads of starch as photos.

3. when iron balls are dropped on the powdered floor

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1, A plate with a hole was put on baby powder which had been filled a box as the same thickness. Which was supposed to be moon surface.

2,Iron balls which were supposed to be falling meteorite models were dropped into the hole.

3,Spreads of baby powder which scattered from the hole were recorded.

3.Experimental Result

In the experiment , we 1 found a positive correlation from the graph between physical energy of the meteorite model and diameter of the ray.

In the experiment 2 , we succeeded to reproduce similar pattern of ray. We intelligence our result and consideration in the poster session.

4.Examination

We thought that the ejectors of ray are considered with falling meteorite and moon surface, but most of powder consisted ray models were ground one. Therefore, we conclude surface powder have high influence.

5.Future issue

The experiments in this study were conducted in an environment different from the lunar surface due to air resistance and the gravity of the earth.

In experiments 1 and 2, it wasn’ t possible to mechanize the manual operation for dropping the powder. As a result, the conditions become uneven.

Conduct an experiment to drop the powder diagonally considering the falling angle of meteorites.

The result of experiment Ⅱ is visual judgment, and examines the correct information processing method such as quantification.

Keywords: Moon, Ray, Meteorite collision

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The Way of Improving Salt-Damaged Soil

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If soils become damaged from salt because of tsunami, plants and vegetables do not grow well. In our last year's research, it was proved that we can improve the salt-damaged soils by adding calcium compounds. So we have tried to find a way of improving salt-damaged soils by adding natural calcium, such as shells. We examined the effects of natural calcium on the growth of radish sprouts and the relations between the amounts of calcium compounds and the remaining Na^{+}.

Keywords: Salt damage, Soil, Calcium

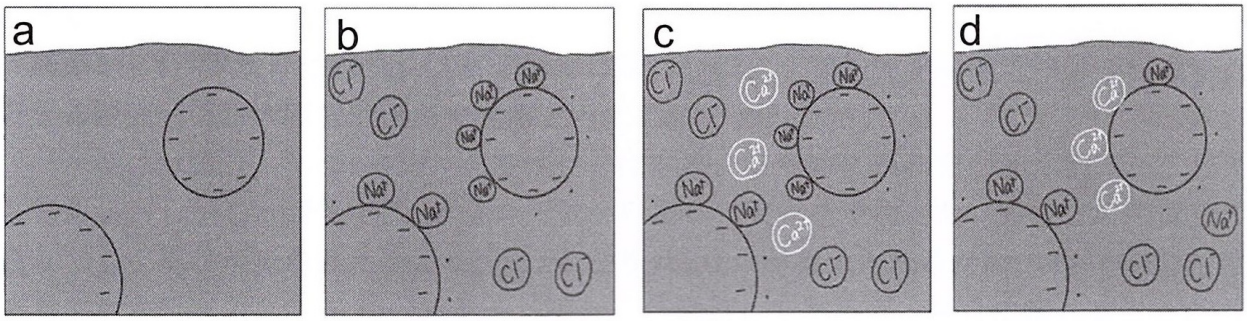

図１　塩害と土壌改良の原理

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Prediction and survey of moonlight power generation amounts –Development of new electricity generation system “Mr. Nisshin Geppo”

*Takaaki Ishimoto[1], *Ryota Suzuki[1], *Koichi Sato[1], *Yuki Yonemura[1], *Hajime Yamamoto[1], *Tatsuya Amamiya[1], *Shinya Amamiya[1]

1. Chuo University Junior and Senior High School

We have developed "Mr. Nisshin Geppo", a device equipped with a solar panel on an equatorial mount for an astronomical telescope. It can generate power while tracking the sun and the moon automatically. In the previous studies, we created a predictive formula for the amount of moonlight power by using an LED bulb, which simulated the power of moonlight. However, the error between the actual amounts and the predicted amounts of moonlight power generation was 64.5%, so we thought that there were some problems regarding the accuracy of the predictive formula. In this study, we have improved on previous predictive formulas by creating a new kind of predictive formula.

Two experiments were carried out in this study:

Experiment 1) Simulated moonlight power experiment: We changed the color of the LED bulb’s light with cellophanes. We measured the amounts of generated power for each cellophane color. We found each wavelength of light had a different influence on the solar panel. The amounts obtained approximated the actual amounts with the relation between the wavelengths and the light’s energy (moonlight spectrums). We measured the laboratory’s brightness with a “Sky Quality Meter” (SQM) and also took the magnitude into consideration.

Experiment 2) Actual moonlight power experiment: We generated power with “Mr. Nisshin Geppo” and measured the amount of moonlight power. At the same time, we also measured the magnitudes of the night sky with SQM. We calculated the predicted amounts by considering the obtained magnitudes and the new predictive formula.

As a result, we calculated the error between the actual amounts and the predicted amounts. In addition, we considered further improvements for the accuracy of this new predictive formula. Details of this study will be presented during the poster session.

Keywords: Moon, Electricity Generation, Tracking

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Filtering capability of fossil coral skeletons *Porites* sp. and *Favia* sp.

*Yuki Ishisaka[1]

1. Chuo University Senior High School

This study has focused on the filtration capacity of the fossil coral skeleton for resource utilization. Three experiments (water passing experiment, filtration experiments with chalk powder and black ink) were performed using fossil *Porites* sp. and fossil *Favia* sp. collected from Kikai Island, Kagoshima, Japan. Water passing experiment revealed that *Porites* skeleton passes distilled water. In the filtration experiments, *Porites* skeleton showed a filtration capacity, while, *Favia* skeleton did not show the capability. The chalk powder was filtered by *Porites* skeleton; however, the black ink was not filtered due to the particle size. This study suggests that fossil coral skeletons have the potential for effective resource utilization.

Keywords: fossil coral skeleton, filtering capability, Kikai Island, resource utilization

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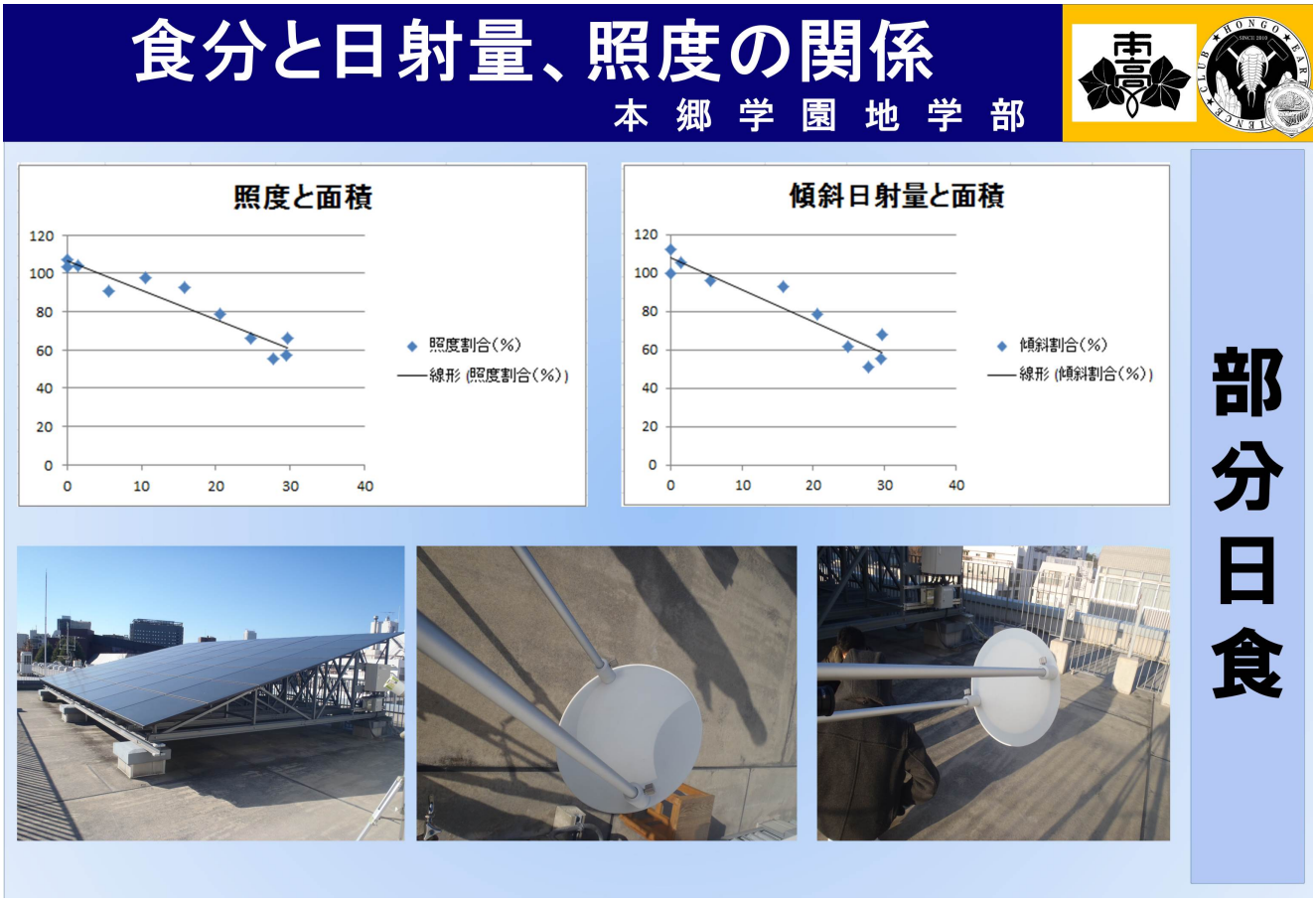
Relationship between the eclipse of partial eclipse and solar radiation and illumination intensity

*Satoshi Yamamoto[1]

1. Hongo senior high school

Partial solar eclipses were seen across the country in Japan for the first time in about three years from 8:40 to 11:30 on Sunday, January 6, 2019. So on January 6th and January 7th, we measured and compared the amount of solar radiation and illuminance every 10 minutes from 8 o'clock to 12 o'clock on the roof of the school. The amount of solar radiation was measured using solar panels, and the illuminance was measured manually using a luminometer. In addition, it was not possible to measure an accurate value because it became clouded after 10:20 on January 6. The ratio of the solar radiation and the illuminance on January 6 to the solar radiation and the illuminance on January 7 was determined and graphed. As a result, both the amount of solar radiation and the illuminance decreased gradually from around 9 o'clock, and the minimum value was recorded at 9:50. From the measurement results, it was thought that there is a relationship between the ratio of the missing area of the sun, the amount of solar radiation, and the change in illuminance. Therefore, we used the solar eclipse calculation software to calculate the diameter of the sun and the moon and the amount of food for each measurement time, and we conducted reproducible experiment from this data and considered it.

Keywords: Partial solar eclipses, Solar radiation , Illuminance



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How much can the revolution of the moon be explained by the second law of Kepler?

*Kana Uchida[1], *Haruki Kobata[1], *Toa Hattori[1], Shuhei Asano[1], Mamiko Usui[1]

1. GIZAN SENIOR HIGH SCHOOL

We have been researching the phases of the moon since 2016 .
We researched with the ratio of the shining part of the moon which changes with the moon cycle.
We called this ratio “luminous rate”.
First, a model experiment was conducted to obtain a formula for explaining the change in the luminous surface ratio.
Then, the value obtained by this formula was compared with the light emission area obtained from the image of the actual moon.
As a result, we confirmed that the change of the distance between the earth and the moon was not constant.
It was thought that the cause was influenced by Kepler’s second law.
We hope to find a formula for each pattern, we compare the pattern of luminous rate per cycle for each moon cycle.
For that purpose, we compared the values of tha astronomical almac and the calculated values,
And also made a graph of the values of the astronomical almac and the distance.

Keywords: Waxing and waning of the Moon, Orbit of the Moon, Kepler's laws

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The formation age and environment of the Tubo River outcrop,Seki in Gifu prefecture, Central Japan.

*Yuya Yamada[1], *Keisuke Ohno[1]

1. GIZAN SENIOR HIGH SCHOOL

In the research concluded until last year, the outcrop of Tubo River that flows through Shimokurachi in Seki city Gifu prefecture is stream deposit by the pumice Old Kiso River that erupted at Mt.Ontake about 60 to 90 thousand years ago.

This study, the pumice of this outcrop and several pumice collected in the standard outcrop of Mt.Ontake tephra in Ina city, Nagano prefecture are compared from the characteristics of heavy mineral composition and Hypersthene. As a result, this outcrop included pumice called On Pm- Ⅰ ,On-In, On-Mt. Also, From the deposition structure of this outcrop, the abandonment of the diversion toward the Seki city of the Old Kiso River is considered to have occurred about 60 to 55 thousand years ago, integrated with other previous research.

Keywords: Late Pleistocene, Ontake volcano, Stream deposits

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The change with time of the gigantic jet off the coast of Ibaraki on December 11, 2017 and comparison with the past jets

*Naoya Yamashita[1], *Shin Hirano[1], *Hayato Matsuyama[1], *Yuya Okubo[1]

1. Shizuoka Prefectural Iwata Minami High School

Our school and Aoyama Gakuin University observed a kind of gigantic jet of transient luminous events on December 11, 2017. The occurrence point is identified with Ibaraki prefecture off the coast by way of the triangulation from 2 points, and the upper altitude is 66.3km Also, we examined the gigantic jet by dividing it into five parts based on the characteristics of light emission. As a result, it becomes clear that the upper part emits light first, and after the light emission weakens, that of the lower part become stronger. Furthermore, it was considered that the gigantic jet was triggered by a discharge in the cloud due to the accumulation of a large amount of electrical charge in the troposphere, in comparison with the weather observation record and the previous research. In addition to them, we compared this jet with the three past gigantic jets and found out common and different points. As common points, all four jets occurred from late November to mid-December, and they almost didn’ t have rain. But their shape, altitude and light emission time are very different.

Keywords: gigantic jet, troposphere

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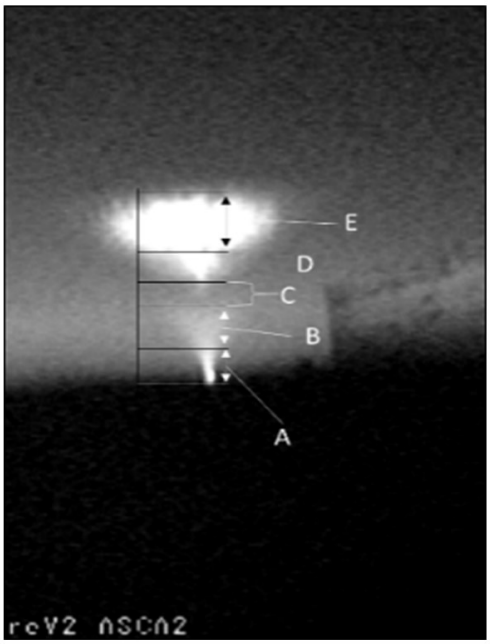


図1 ジェットの高度別の特徴
(青山学院大学段毛毛氏撮影)

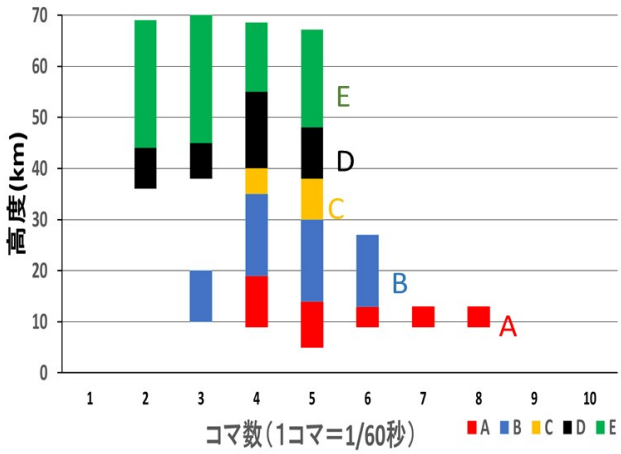


図2 ジェットの高度別の時間変化

表1 今回と過去三回の巨大ジェットの比較

	2008年の巨大ジェット	2010年11月の巨大ジェット	2010年12月の巨大ジェット	今回の巨大ジェット
発生地点	陸上（石川県）	海上（鳥取県沖）	海上（能登半島沖）	海上（茨城県沖）
上端高度	99.3km	120km	108.1km	66.3km
発光時間	約42/60秒	約8/60秒	約6/60秒	約7/60秒
形状	接木状	一体状	一体状	一体状
発生時期	11月下旬	11月下旬	12月上旬	12月中旬
前後の雨量	ほぼなし	ほぼなし	ほぼなし	ほぼなし
雲内放電	あり	不明	あり	あり
対地雷	なし	なし	不明	なし

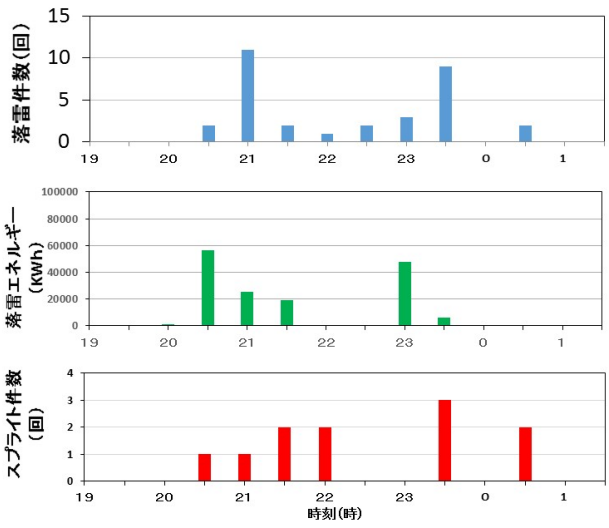
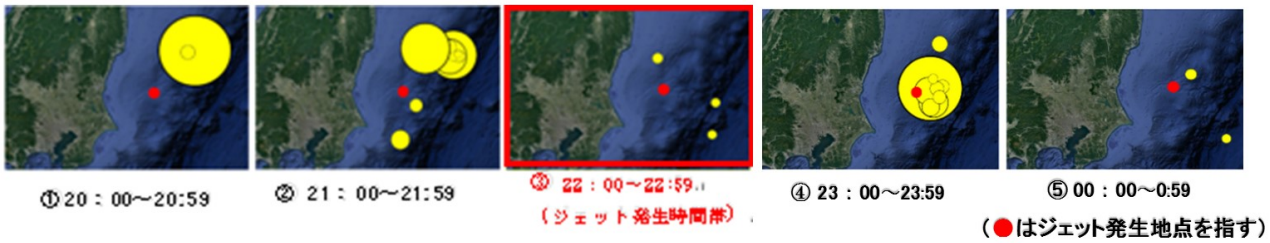


図3 落雷の発生回数とエネルギー，スプライトの発生回数の時間変化



（●はジェット発生地点を指す）

図4 落雷発生地点（半径＝√エネルギー値，Google Earth(https://www.google.co.jp/intl/ja/earth/)を使用）

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Reconstruction of Late Holocene environmental changes based on analysis ofcore sediments from Kaicho Temple

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1. Shizuoka Prefectural Iwata Minami High School

1.Introduction

Studies of historical records show that many Mw 8 class earthquakes have occurred along the Nankai and Suruga troughs, central Japan, with a recurrence interval of 90–270 years since the AD 684 earthquake. Coseismic uplift did not recorded during the 1707 Hoei and 1498 Meio earthquakes, but the AD 1854 Ansei-Tokai earthquake caused coseismic uplift of ~1 m in coastal areas west of Suruga Bay, including the Shimizu Plain. Thus, we studied the environmental changes of late Holocene from the geological record of Kaicho Temple in Shimizu-ku, Shizuoka city, Shizuoka Prefecture, and examined the history of coseismic uplift prior to the 1498 Meio earthquake. The temple was built at AD 1011 in the beach ridge at an altitude of about 4 m. (Fig.1) This history can help to constraint age of emergence of land in the study area.

2.Method

We drilled two 14m boring cores, cut the core in the vertical direction, investigated deposits, took soft X-ray photographs and made columnar sections. (Fig.2) We used ^{14}C dating of leaves. We collected and preserve core samples every 1 cm. We analyzed the grain size and performed CNS elemental analysis.

3.Result

At site 1, deposits change upward from gravelly sand, through clay to alternations of sand and gravel beds. Gravelly sand and clay yield many intertidal molluscs such as *Umbonium moniliferum*. Foraminifera is not found from clay. The C/S ratio in clay deposit is ~0.7, except for the most upper part (6.3). The boundary between clay and well-sorted fine-grained sand is sharp. Alternations of sand and gravel beds yield wood fragments but not molluscs.^{14}C ages of leaves from the clay show AD 398 to 539.

At site 2, deposits change upward from sand, through clay to alternations of sand and gravel beds. Lower sand and clay beds yield molluscs. Foraminifera is not found from clay. The C/S ratio in clay deposit is 0.6-1.0. The boundary between clay and well-sorted fine-grained sand is sharp. In X-ray photograph, weak lamina can be observed in fine-grained sand. A woody debris bed with open matrix is found from sand and gravel beds. The ^{14}C age of leaves in woody debris bed represent AD 258 to 428.

4.Discussion

Based on occurrence of intertidal molluscs, we think that the clay bed at -0.45-0.25 m above sea level (core depth: 4.90-4.20 m) at site 1 and at -0.12-0.20 m above sea level (core depth: 3.92-3.60 m) at site 2 were deposited in muddy tidal flat. This interpretation is supported by C/S ratio. The clay bed is overline by alternation of sand and gravel beds. Sand beds are characterized by good size sorting and weak lamina. There is a woody debris bed in alternation of sand and gravel beds. These are commonly found in deposits in the backshore area which is only exposed to waves under extreme events with high tide and

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storm surge. The uppermost gravel bed is interpreted as deposits of beach ridge.

It is noteworthy that sedimentary environment changed from intertidal muddy tidal flat to backshore area. Since shoreface area exists between both areas, a lack of shoreface deposit indicates that relative sea-level fell abruptly. Based on ^{14}C age of leaves, sea-level fall took place at AD 398-428. Because eustatic sea-level was stable in this interval, abrupt sea-level fall can be interpreted as coseismic uplift.

5.Conclusion

To clarify the history of large earthquakes along Suruga Trough, central Japan, we studied the sediment, fossil contents and TS contents of two sediment cores collected at Kaichoji Temple in the coastal area of the Shimizu Plain. The results can be summarized as follows.

1: We identified the sharp boundary in lithology between the clayey deposit and the overlying well-sorted sandy deposit at 0.20-0.25 m above sea level. This change indicates that sedimentary environments suddenly changed from tidal muddy flat to backshore area, suggesting coseismic uplift associated with rupture of Suruga Trough.

2: The results of ^{14}C dating show that the uplift took place at AD 398-428.

Keywords: coseismic uplift, Nankai and Suruga troughs, late Holocene, Shimizu Plain, facies analysis

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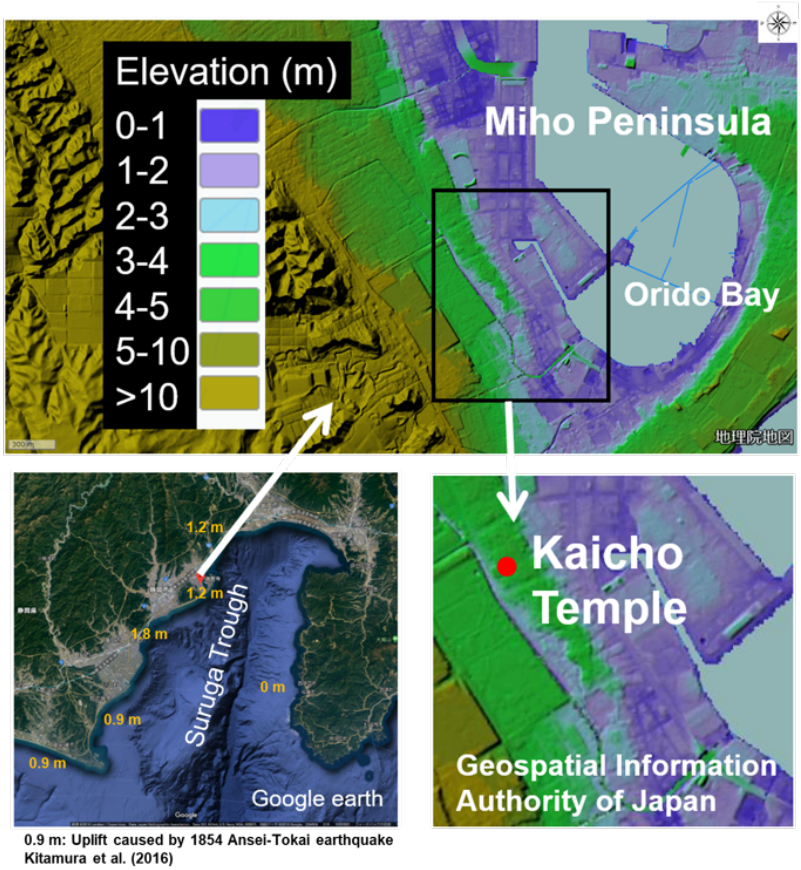

fig. 1 Study area

0.9 m: Uplift caused by 1854 Ansei-Tokai earthquake
Kitamura et al. (2016)

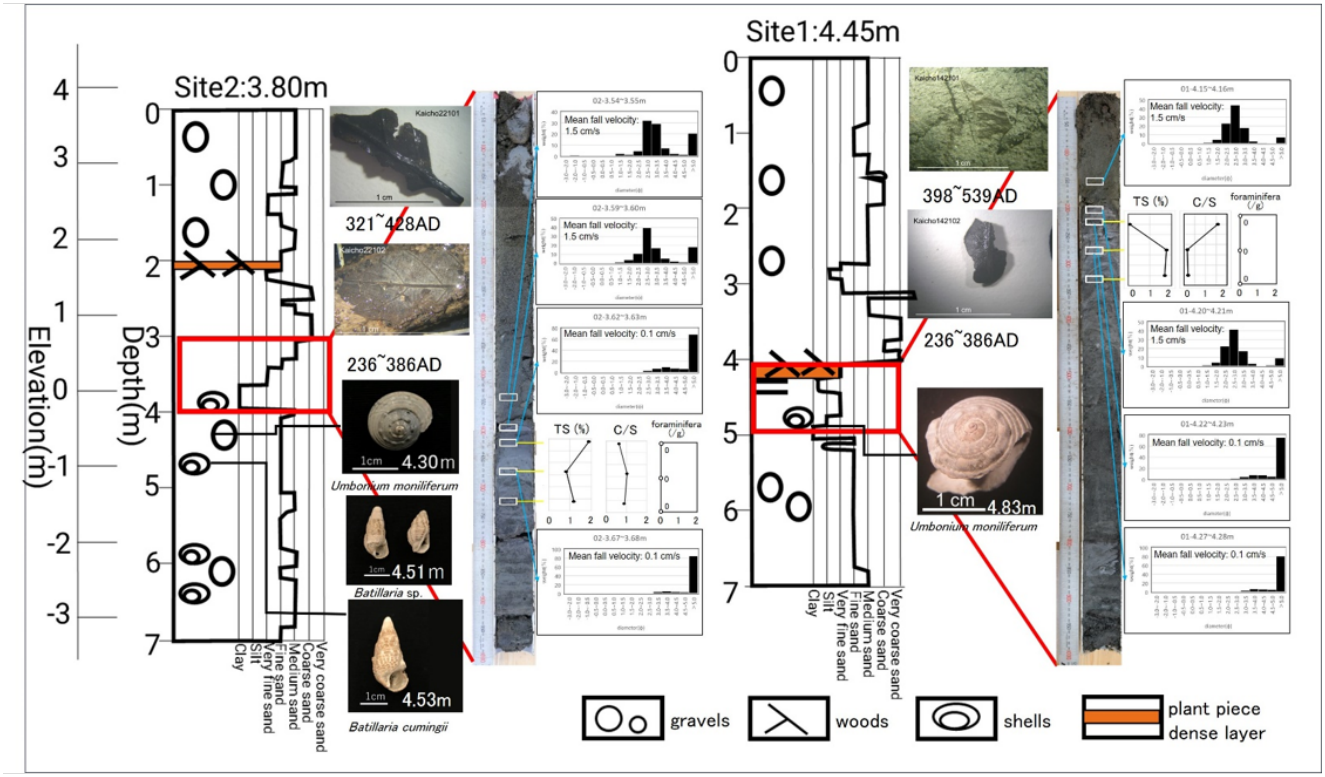

fig. 2 Columnar sections

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generation of 3D model on the coast of Samejima,the sea of Enshu and detection of coastline by drones

*Eito Takagi[1]

1. Shizuoka Prefectural Iwata Minami High School

1. Background・Purpose

It is clear from the past study of Iwata Minami High School area department that the coastal erosion on the coast of Samejima, the sea of Enshu(fig.1) is in progress. In order to study the coastal erosion, we perform leveling with auto level and hand level. However, leveling by human work requires much time and effort. So we focused on the drone we had on the headquarters club(fig.2). We thought, "Can we do surveying efficiently by using this drone", we decided to work on research activities with the goal of increasing the efficiency of surveying with drone.

2. 3-D point clouds

Last year ago, we conducted a 3-D reconstruction method using drone.

First, I captured videos of the coast of Samejima with a drone. After that, the image is extracted from the captured videos. 3-D point sets are generated from an image acquired using 3-D point set reconstruction processing software(fig.3). This makes it possible to create a reconstruction point group of the coast. However, the scale of the reconstruction point cloud is different from the actual coast. Therefore, based on the size of the actual blue sheet used for shooting, the blue sheet in the point cloud is subjected to enlargement and contraction processing. This allows the entire point cloud to be scaled to the actual scale.

We also performed leveling with auto level and hand level to check how accurate the acquired data are.

3. Detecting the coastline

This year, we detected coastlines from 3D point clouds(fig.5). First, the point cloud on the coast is divided into strips elongated in the y direction. Subsequently, each strip is divided in the z direction at regular intervals by processing by the program. Furthermore, for the cut ones, the variance is calculated in each range.

Finally, determine the threshold and record where the variance value exceeds the threshold. Then draw. As a result, the shoreline was successfully detected, and it was possible to identify the coast and the sea.

4. Discussions

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This time, we succeeded in 3-D reconstruction of Samejima coast and detection of the coastline. First, comparisons were made using data of elevations measured using a surveying instrument and data of point clouds at the same points surveyed(fig.4). In addition, when performing comparison, it was based on the data acquired using a surveying instrument. When the two data were put together on the graph, it was possible to confirm the part where they coincide and the part where a large error occurred.

These errors were larger at the measurement start point and at the part near the shoreline.

Then, the coastline was also detected using the acquired 3-D point clouds. Since the threshold was artificially determined, it was possible to detect the coastline closer to the actual coast by freely changing the threshold. However, in the method performed this time, human work was very much.

Therefore, it is not completely applied to "to conduct surveying efficiently" which is the main purpose of this study.

5. Conclusion・Future outlook

In this study, we captured videos of a beach using a drone and succeeded in 3-D reconstruction on the coast of Samejima, the sea of Enshu. However, when comparing the data obtained from leveling and point cloud, a part where a large error occurs in the elevation was confirmed. Improvement is expected by improving the accuracy of reconstruction using a laser scanner. The operation of a drone equipped with a laser scanner also requires safety considerations.

We also succeeded in detecting the coastline from the acquired 3-D point clouds. As a result, it was possible to identify the beach and the sea. However, the method of coastline detection conducted this time has many artificial parts. Therefore, it is necessary to repeat the discovery of improvement points, the proposal of new methods, and the execution for the purpose of study “efficiency of surveying”.

Keywords: drone, the coast of Samejima, 3-D point clouds

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図1　鮫島海岸の位置

図2　撮影に用いたドローン
（DJI　PHANTOM3 STANDARD）

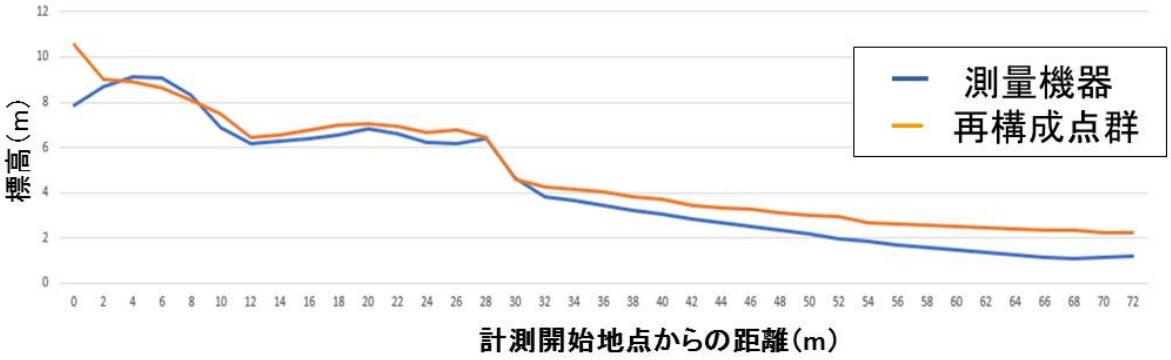

図4　測量結果の比較

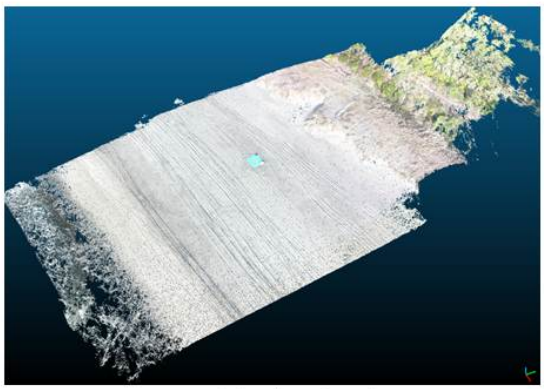

図3　鮫島海岸の
三次元点群画像

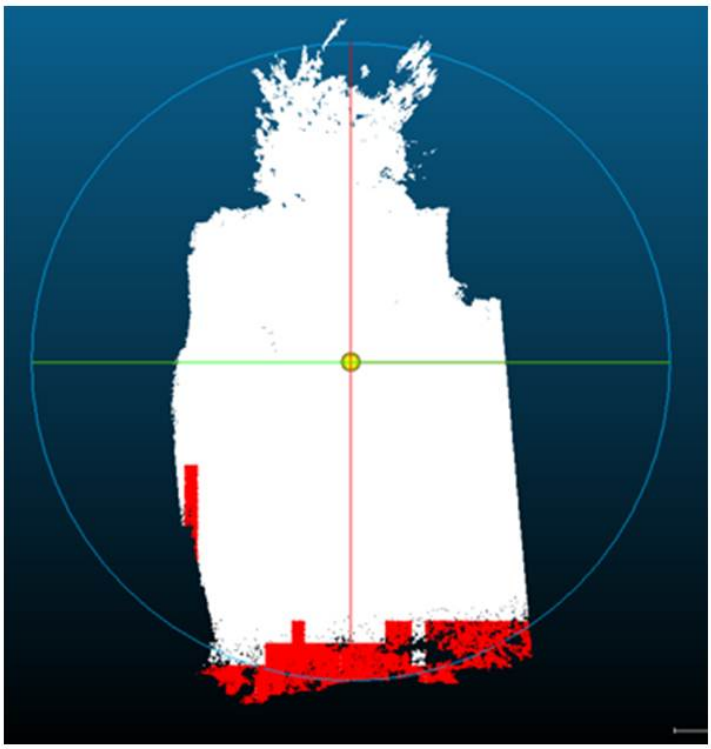

図5　海岸線が検出された海岸
海（赤色）　　陸（白色）

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Factors of beach change on the Ose coast in Ibaraki prefecture

*Kaito Kotsuti[1], *Kosuke Shimano[1], *Haruto Sakachi[1], *Fuyu Tokuda[1], *Syunsuke Nagayama[1], *Hiroki Nemoto[1], *Towa Murakami[1], *Yuki Mimori[1], *Yasushi Wada[1], Takemi Ogawa[1], Eri Yoshida[1]

1. Ibaraki Prefectural Hitachi First Senior High School

[Introduction]

In recent years, the impact of coastal erosion has been reported in the north of the coast of Ibaraki Prefecture (Uda etl,2008). We examined by using aerial photograghs the situation of shoreline of Ose coast in Hitachi City. As a result, it seemed that coastal erosion occurred on the Ose coast. So, we started this study.

[Purpose]

The purpose of this study is to examine the situation of the beach change on the Ose Coast and to examine the beach change factor.

[Overview of the Ose coast]

Ose coast is located about 1km away south from Hitachi Station. Ose coast lies between Ose fishing port and abrasion platform. Sea cliffs are located behind the coast. The length of the coast is about 100m of sandy beach. The sediments on the Ose coast were mainly medium sand and coarse sand.

[Experiments and results]

During the three year study period, the average elevation value fluctuated between 239.3 and 156.3 cm. And the foreshore part was the most fluctuating than the backshore .

[Consideration]

From the result of concentration of the fluctuating field in the coastal area, we consider points of "coastal flow".

coastal flow

We used ocean buoys located about 5 km off the Ose coast to examine the coastal flow over the past four years. As a result, three of the southeast (10%), the south (16%), the southwest (21%) are predominant, and we named them "south-facing coastal flow". The proportion of this "south-facing coastal flow" was inversely proportional to the increase and decrease of the average altitude. There was a slight negative correlation between coastal flow and average altitude.

El nino

The fluctuation of the coastal flow is not a seasonal. So we examined the relationship with the El Nino. As a result, correlation was seen that between the ratio of south-facing coastal currents and the El Nino

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monitored area. Therefore, the topography change of the Ose coast may have something to do with the occurrence of the El Nino.

[References]

Takaaki UDA, Toshiro SAN-NAMI, Hideki NAGAYAMA, Michio SUMIYA and Takayuki KUMADA,(2008) : BEACH EROSION ON NARUSAWA, TAGA AND KAWARAGO COASTS IN IBARAKI PREFECTURE, Annual journal of civil engineering in the ocean, 24,pp1327-1332

Keywords: beach change , coastal flow, El Nino

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Hiraodai and Hirotani Wetland Research of soil hardness and water sources + Ramsar Convention

Mariko Hirota[1], *Yujin Ito[1], *Natsuki Abe[1]

1. Higashichikushi Gakuen High school

We are researching from the viewpoint of origin, increase and decrease, and regeneration of Hirotani Wetland which is the only karst plateau in Japan, located in Hiraodai. The research was conducted last year focusing on the following three points.

・ Quantification of wetland boundaries by soil hardness

・ Flow analysis of water by stable isotope

・ Ramsar Convention registration activities ... Conservation activities of Hiraodai + Hirotani Wetland

Hirotani Wetland, between 1994, when we started the survey, and 2010, more than 60% of its area was vanished. We think that artificial trail construction for conservation in 1998 lead devastation of the wetland. We thought it is human being' s responsibility to restore the damage done by human beings. We used Satoyama methods and started three restoration activities. First was maintenance of stone stackings to raise the underground water level. Second was adjustment of damming plate to make origin of underground water. Third was pulling up fallen reeds to revive seeds of wetland plants. By those activities, we succeeded to restore the wetland's area for 105% by 2017.

Wetlands are often considered from vegetation. However, the wetland boundary was quantified using soil hardness as a new wetland investigation method. I thought that the border between the grasslands and the wetlands in the Hirotani Wetland is about 7 mm, but in order to make it even more universal, surveys were also conducted in the Tadewara Marsh in Oita Prefecture and the Kushiro wetland in Hokkaido. The boundary value of the soil hardness of the grassland and the wetland is 8 to 9 mm, which proves the validity of the boundary value in the Hirotani Wetland. It is thought that wetland research by the geologic approach called surveying has made great progress.

Water was analyzed using stable isotopes to determine the origin of water in the Hirotani Wetland. From the results, a graph of the relative ratio between the celestial water line and the Hirotani Wetland was created, and when the approximate line of each measured point was taken, a straight line with almost the same slope as the celestial water line was found. Therefore, it turned out that the groundwater of the Hirotani Wetland originates from rainwater. Furthermore, from the intercept of the approximation line, it was considered that the water was seven months ago from March when it was sampled. However, for the first time to consider stable isotopes, we were taught by that who is studying stable isotopes at Tohoku University. It has been pointed out that dynamic classification is involved and complicated, and the width of this data can not be considered in detail. It seems that it was early to give concrete results. After all, I felt that it was difficult for high school students to study stable isotopes that could not handle analytical instruments.

In addition, as part of applied ecology, we are engaged in Ramsar Convention registration activities of Hiraodai and Hirotani Wetlands. The Ramsar Convention is a wide-ranging international treaty related to

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biodiversity, and Akiyoshidai in Yamaguchi Prefecture is also registered, etc. The Ramsar Convention registration is the most important condition that local approval is agreed. Therefore we made a petition to Kitakyushu city council in addition to the presentation of the company and event hosted by prefecture, city. The petition of a high school student was the first time, was taken up by media companies, and local people were able to have a broad understanding of registration activities. With this petition, Kitakyushu City and Fukuoka Prefecture have also officially launched for Ramsar Convention registration. We will continue various appealing activities in the future, and want to convey the wonderfulness of Hiraodai + Hirotani Wetlands to more people. The challenge of the international treaty by high school students, which was not dealt with by anyone, is likely to bear fruit. And the Hirotani wetlands are also likely to make great strides in their conservation.

Keywords: Hiraodai karst, Hirotani Wetland, Soil hardness, Stable isotope, Biodiversity, Ramsar Convention

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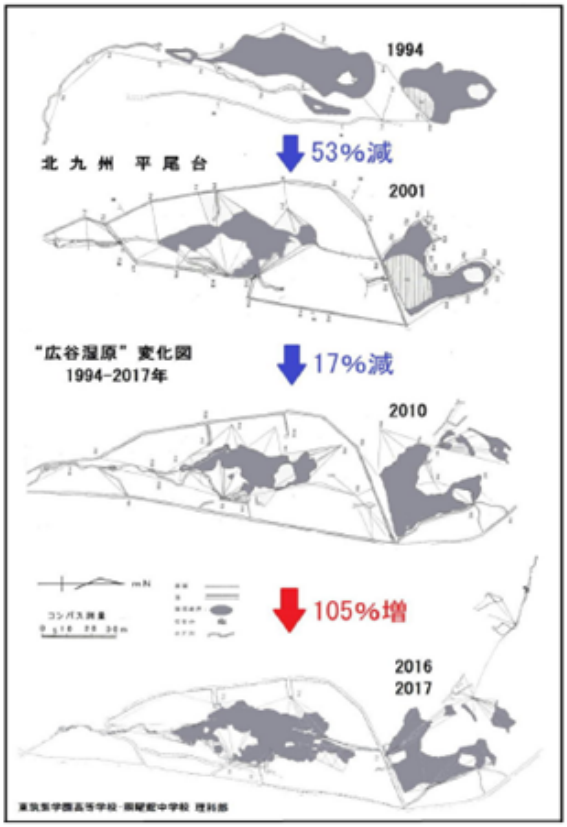
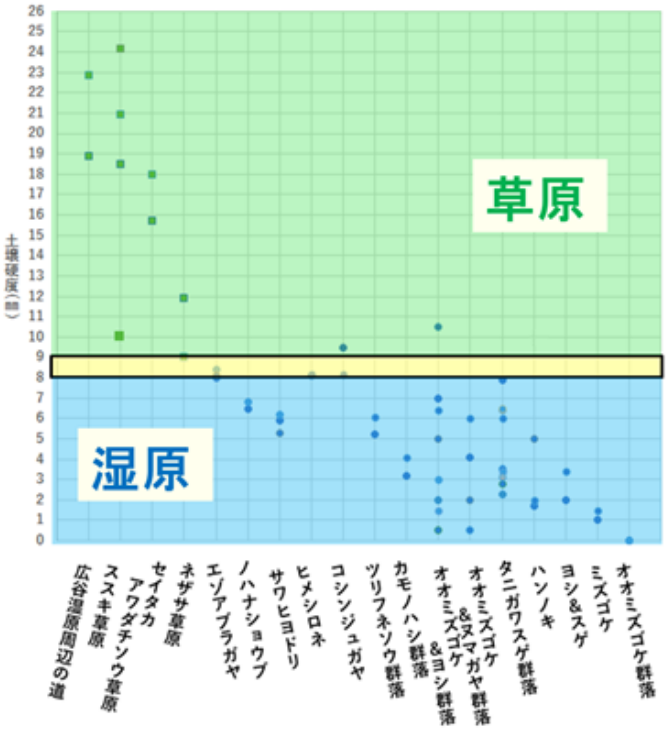
▼写真1　カルスト台地 平尾台

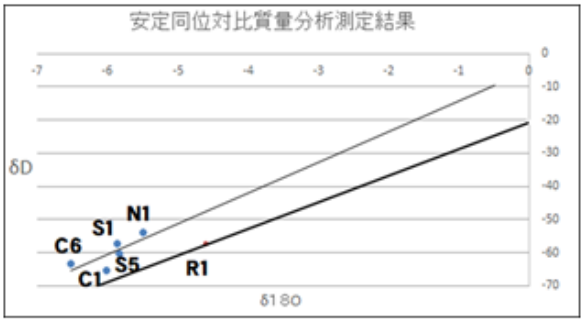
▼図1　湿原の増減図（1994～2017）



▼図2　植生による土壌硬度のグラフ



▼図3　天水線と広谷湿原の相対比グラフ



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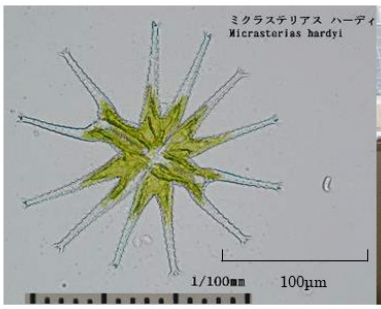
Ecological study on *Micrasterias hardyi* recently invaded to Lake Biwa: its dependency on water temperature

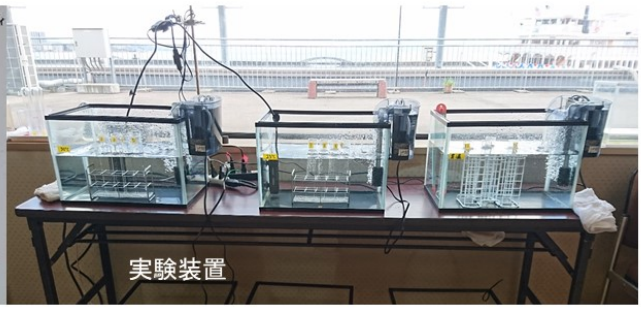
*Ayane Kawai[1], Michio Kumagai[2]

1. Shiga Prefectural Ishiyama High School, 2. Authorised NPO Biwako Trust

In August 2016, I saw *Micrasterias hardyi* at first, which is an invaded phytoplankton in Lake Biwa, and I was attracted by its beautiful microscopic shape. *Micrasterias hardyi* made a big bloom in Lake Biwa in 2016, and became in a comparative lull in 2017, but it increased rapidly again in 2018. I have studied the morphology, vertical distribution and settling velocity of *Micrasterias hardyi* since then. This time, as I made laboratory experiment to understand the dependency of *Micrasterias hardyi* on water temperature, I will show the results.

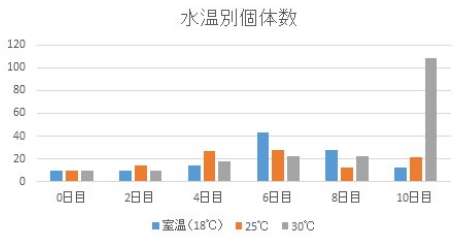
Keywords: Micrasterias hardyi, Lake Biwa, water temperature





水温別個体数変化（個体）

水温	0日目	2日目	4日目	6日目	8日目	10日目
室温(18℃)	10	10	14	43	28	12
25℃	10	14	27	28	12	21
30℃	10	10	18	22	22	108



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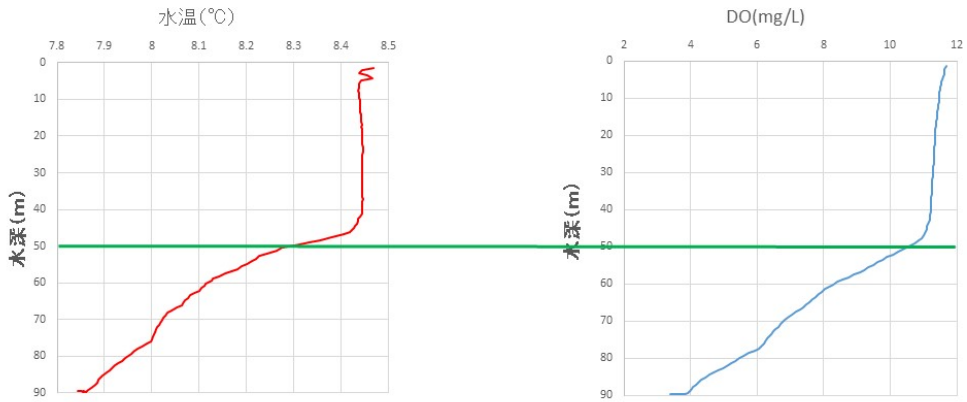
Changing environments on the earth –first termination of overturning in Lake Biwa

*Hinata So[1], Michio Kumagai[2]

1. Shiga Prefectural Zeze High School, 2. Authorized NPO Biwako Trust

Due to warm winter, overturning in Lake Biwa, which happens every year, has stopped this year for the first time. This sort of serious phenomena has not been reported during last 100 years. What is the cause of termination of overturning? How does it effect on the benthic animals and water quality in the deep water of the lake? What are coming on the environments next year or year after next year? We compare the present data with the filed data in the past and analyze them, and then discuss the possible change in future environments of Lake Biwa.

Keywords: overturning, Lake Biwa, environment



琵琶湖北湖第一湖盆での水温と溶存酸素濃度（2019年3月24日）
水深50m以深が混合していない！

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Let’ s solve the mystery of gyre drift toward north !

*Masaki Tsuji[1], Michio Kumagai[2]

1. Shiga Prefectural Zeze High School, 2. Authorized NPO Biwako Trust

There is a spiral current which moves to counterclockwise during stratified period in Lake Biwa. This is generally called gyre, and it is thought that the gyre is kept by balance with pressure gradient and rotation of the earth. We discussed the changes of gyre motion using the position information of gyre observed by two drifting buoys. The center of gyre shifted toward north about three kilometers during the field experiment. Also, we found that the wind blew from east to west during almost 24 hours at about four to five meters per second. From these results, we deduced the possibility of gyre movement toward north due to Ekman drift currents which were caused by east wind. In addition, we inspected the presence of geostrophic gyre which governs water quality distribution such as water temperature, chlorophyll-a, dissolved oxygen and so on.

Keywords: Lake Biwa, gyre, Ekman transport

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Exploring Atmospheric Properties from Color Change Observation of the International Space Station

Kuroiwa Hiroaki[1], *Ishimura Daiki[1], *Kurohabaki Nanami[1], *Takizawa Shizuku[1], *Yamamoto Yuka[1]

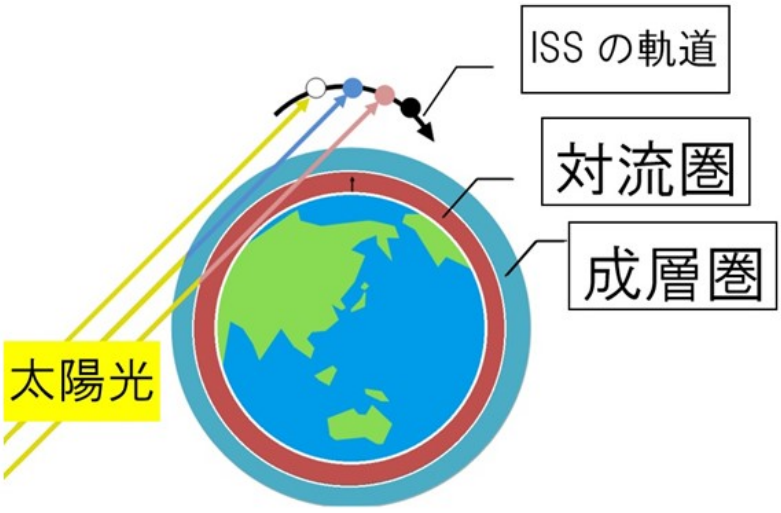
1. Iiyama Senior High School

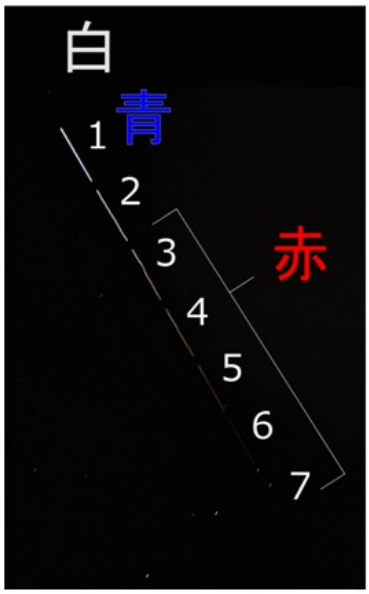
The purpose of this study is to attempt to make a low cost ozone map. The images of the ISS(the International Space Station) change their color from white to blue to red when the ISS appears and disappears. According to NASA’s Science News(Dec.2011) the blue hue becomes stronger when sunlight passes through the ozone layer. In this study, we assume that the blue hue reflected from the ISS deepens as the ozone layer thickens. First, we photographed the ISS’s light trails and measured RGB values, especially focusing on the B color code. Second, we estimated the ISS’s positions and distance traveled through our photographs by comparing our the times at the beginning and end of each exposure and the total time elapsed in the composite image with the JAXA *Kibo o miyo* ISS location map. From these data, we researched the relationship between the amount of ozone and observed color changes of the ISS in our photographs. In conclusion, it is likely possible to create an accurate ozone layer map by using amateur pictures of the ISS. This method could replace current costly observation techniques.

Keywords: International Space Station, ozone layer

ISSの色変化から探る大気の性質

長野県飯山高等学校　石村大樹　黒鋼七海　滝澤しずく 山本友佳





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Re-examination of capillary phenomena with gravity as a variable : Second report

*Koushi Hashimoto[1], *Haruka Ono[1], *Riku Nakaima[1], *Takeo Matsuda[1], *Yoshie Sawazaki[1], *Takako Yamashita[1], *Takeru Wakabayashi[1]

1. Otemae Senior High School of Osaka prefecture : the evening course

Surface tension acts on the liquid to reduce its surface area. In a thin tube, the phenomenon that the liquid surface rises due to surface tension is well known as capillary phenomenon. According to theory, the height of this liquid level is inversely proportional to the radius of the tube and gravity. Experiments with varying tube radius have been made up to now, and it has been confirmed that the relationship between liquid level and tube radius follows a theoretical formula. We have an apparatus to change gravity. Therefore, we tried to confirm experimentally whether the relationship between gravity and the height of the liquid level also follows the theoretical formula. When water was used as the liquid sample, the height of the liquid level did not follow the theoretical formula, and the rise stopped at a certain gravity value. However, in the case of ethanol, the liquid level increased according to the theoretical formula. Based on this experimental result, we discuss the theoretical formula and the experimental method.

Keywords: Capillary phenomenon, gravity, Gravity variable apparatus

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The Study of Kabutoyama

*Manami Nakazawa[1], *Masahiro Okuyama[1], Dai Iijima[1], Haruta Moriya[1], Ayato Watanabe[1]

1. Yamanashi prefectural Hikawa Highschool

”The Kabutoyama” of northern part of Kofu Basin are mountains of a helmet-shaped.
We studied Mizugamori volcano distributed over the northern part in the past. This study is intended to clarify it about the difference in characteristic in search of the border with the Mizugamori volcano.
We understand that mudstone and andesite are distributed by an investigation in the outdoors and make a geologic map now.

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Proposal of GEO-KAMISHIBAI that enhances the appeal of SANRIKU Geopark and conveys it in an easy-to-understand.

*Keisei Yasuhara[1], *Kana Kato[1], *Mizuho Gondai[1], *Arisa Okubo[1], *Haruto Kawasaki[1], *Mai Kawabata[1], *Seiya Yoshida[1], *Hitomi Kimura[1]

1. Mariento Chikyu Tanken Club Senior

The Sanriku Geopark covers the area from Aomori Prefecture through the coast of Iwate Prefecture and down to Miyagi Prefecture. Hachinohe City Marine Science Museum is located on the northern edge of that and to that belongs to the Mariento Chikyu Tanken club.

We learned about Sanriku Geopark in March 2019. There are seven geosites in the Sanriku Geopark northern area. They are shown in Figures 1. After lectures by Sanriku Geopark authorized guide and the field trips, we had many problems such as difficult and unfamiliar technical terms. So we picked difficult terms or mechanism out and drew up a list. And find out them on books, brochures and the website. We rewrote them to an easy-to-understand description for high school students and to the one for elementary school students.

Presenting what we know how a feature of our club. So we propose "GEO-KAMISHIBAI" as one of the solutions to the problem. An example is shown in Figures 2 and 3. Use simple figures and give plain explanations that use as few technical terms as possible. We made it with a keen awareness of living in a changing zone.

It was improved while incorporating expert advice and demonstrated to elementary and junior and senior high school students. We confirmed that we could convey the attractiveness of Geopark in an easy-to-understand and fun way as a result of the questionnaires obtained there. The results of the questionnaire are shown in chart 1.

Through this activity, we were able to realize that we lived on the earth which keeps changing. In addition, the people adapted themselves to various earths' changes many times, and they have made it rather opportunities for the innovation since the Jomon-era. And we want to know wisdom from the geopark. We should not be afraid of earth changing too much and should make it an opportunity of the new innovations. We are trying to improve "GEO-KAMISHIBAI" more and more.

We got the cooperation of Japan Agency for Marine-Earth Science and Technology (JAMSTEC), Hachinohe City, Hachinohe City Board of Education, Korekawa Archaeological Institution, Promotion of Utilization of Research Results by JAMSTEC Hachinohe City Council Meeting Association, the high school to which the members belong and various related organizations. Gratitude is recorded here.

Keywords: Geosites, Sanriku、Geopark, Regional activity, Club activities

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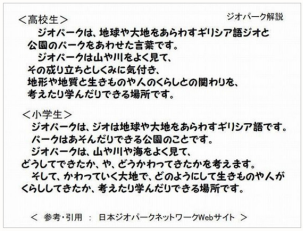
Figuer 1　Geo-sites in the Sanriku Geopark northern area.

図１　三陸北部エリアのジオサイト

図２　ジオ紙しばい　表の一例

Figure 2　Picture of GEO-KAMISHIBAI

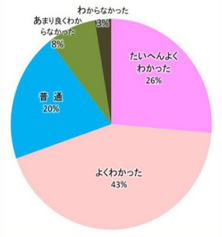

ジオパーク解説

＜高校生＞
ジオパークは、地球や大地をあらわすギリシア語ジオと公園のパークをあわせた言葉です。
ジオパークは山や川をよく見て、その成り立ちとしくみに気付き、地形や地質と生きものやんのくらしとの関わりも、考えたり学んだりできる場所です。

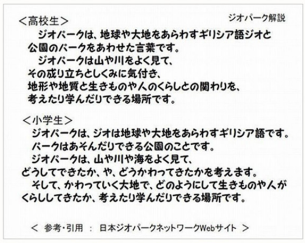
＜小学生＞
ジオパークは、ジオは地球や大地をあらわすギリシア語です。
パークはあそんだりできる公園のことです。
ジオパークは、山や川や海をよく見て、どうしてできたか、や、どうかわってきたかを考えます。
そして、かわっていく大地で、どのようにして生きものやんがくらしてきたか、考えたり学んだりできる場所です。

＜ 参考・引用 ： 日本ジオパークネットワークWebサイト ＞

Figure 3 Description of GEO-KAMISHIBAI



グラフ１　アンケート集計結果


ジオパーク解説

＜高校生＞
ジオパークは、地球や大地をあらわすギリシア語ジオと公園のパークをあわせた言葉です。
ジオパークは山や川をよく見て、その成り立ちとしくみに気付き、地形や地質と生きものやんのくらしとの関わりも、考えたり学んだりできる場所です。

＜小学生＞
ジオパークは、ジオは地球や大地をあらわすギリシア語です。
パークはあそんだりできる公園のことです。
ジオパークは、山や川や海をよく見て、どうしてできたか、や、どうかわってきたかを考えます。
そして、かわっていく大地で、どのようにして生きものやんがくらしてきたか、考えたり学んだりできる場所です。

＜ 参考・引用 ： 日本ジオパークネットワークWebサイト ＞

図３　ジオ紙しばい　裏の一例

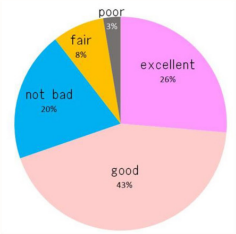


Chart 1　Questionnaire results

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Research of the Fukui Earthquake Fault (Ⅶ)

*Nobuyasu Nagata[1], *Takuma Yoshizawa[1], Shintaro Umeda[1], Reiji Ohigashi[1], Mahiro Tajima[1], Ryuto Kubota[1]

1. Fujishima High School

71 years have passed since the occurrence of “Fukui Earthquake.” Fukui area has overcome a lot of sufferings and has revived from that wretched spectacle. Now, what to do in order not to repeat the tragedy?

The Fukui Earthquake occurred in 1948 with magnitude 7.1, and brought great damage on Fukui prefecture, killing as many as 3769 people there. This is the first large-scale earthquake that occurred directly underneath a modern city and led to set the 7th grade in “Seismic intensity.”

Actually, there exist a lot of active faults including active Fault zone at eastern margin of Fukui plain, which caused the earthquake. Our purpose was to reveal the underground structure through analyzing the seismic wave and we now hope that this research will be some help for disaster prevention in Fukui Prefecture. This research continues for 7 years and we took it over from our senior. We have observed the seismic wave around the active fault zone at eastern margin of Fukui plain with 6 points.

In this research, we studied from 3 respects.

First one is to determine the hypocenters. We determined hypocenters of earthquakes by using “Win-system” in order to accumulate data set, on which our research was based. We determined 47 new hypocenters last year and now have 319 events from the past 7 years.

Another respect is to estimate the underground structure of each observation station from the data of first S wave vibration direction. From the data of seismic wave form, we created hodographs, identify the first vibration directions and pointed out the possibility of existence of cracks and some underground structure from them. This year, we considered what caused the little differences between this year’s data and past ones.

The other respect is to study the structure of active Fault fracture zone at eastern margin of Fukui plain by travel-time analysis for coda waves. In our two observation points (Kanzu, Sakai) inside active Fault zone at eastern margin of Fukui plain, remarkable coda waves are sometimes seen after S waves. According to our senior’s study, they occur because seismic waves which come from extended area of faults zone get to the fault exceeding critical angle and reflect totally. They concluded that the origin of S wave and remarkable coda wave is same by spectrum analysis. On the basis of these, we did travel-time analysis for S waves and remarkable coda waves, and considered the structure of active Fault fracture zone at eastern margin of Fukui plain.

Keywords: Fault zone at eastern margin of Fukui plain, S wave splitting, Coda wave, Travel-time analysis

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福井地震断層の探求Ⅶ

福井県立藤島高等学校

福井地震による被害統計（GHQ調査報告より）	
死者	5,268
負傷者	10,194
全壊家屋数	35,437
半壊家屋数	5,881
焼失家屋数	3,931

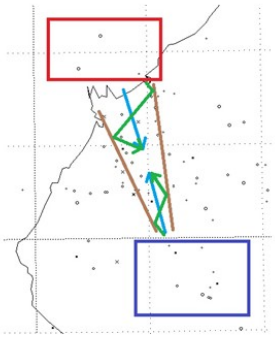

図　福井平野付近

北側の地震の範囲

南側の地震の範囲

S波

後続波

破砕帯の端（イメージ）

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Estimation of sedimentary environment of volcaniclastic deposit and location of craters in the Nomashi formation, Izu Oshima

*Kouki Aida[1]

1. Musashi High School and Junior High School

Izu-Oshima is an active volcano located in the northern end of Izu archipelago. Its eruptive history has been made clear by observing its outcrops. Most of the real surroundings of each eruption such as weather condition and location of crater remains to be confirmed.
In order to clarify the sedimentary environment of eruptions, we investigated the exposures on Mabushi logging road crossing in an east to west direction on the southern part of the island. On this road, we could observe the Younger Oshima group, which is the upper part of rocks in Oshima. In this study, we narrowed down a survey into the Nomashi formation, which is the middle part of the Younger Oshima group. As a result of correlation, we revealed that some of the same layers have laterally continuous variation of thickness and scoria coarseness. We suggest that continuous thickness variation shows the approximate wind direction of the eruption, and continuous scoria coarseness variation shows the approximate location of the craters.

Keywords: Izu Oshima volcano , Younger Oshima group, tephra thickness, scoria coarseness, wind direction of eruption, location of volcanic crater

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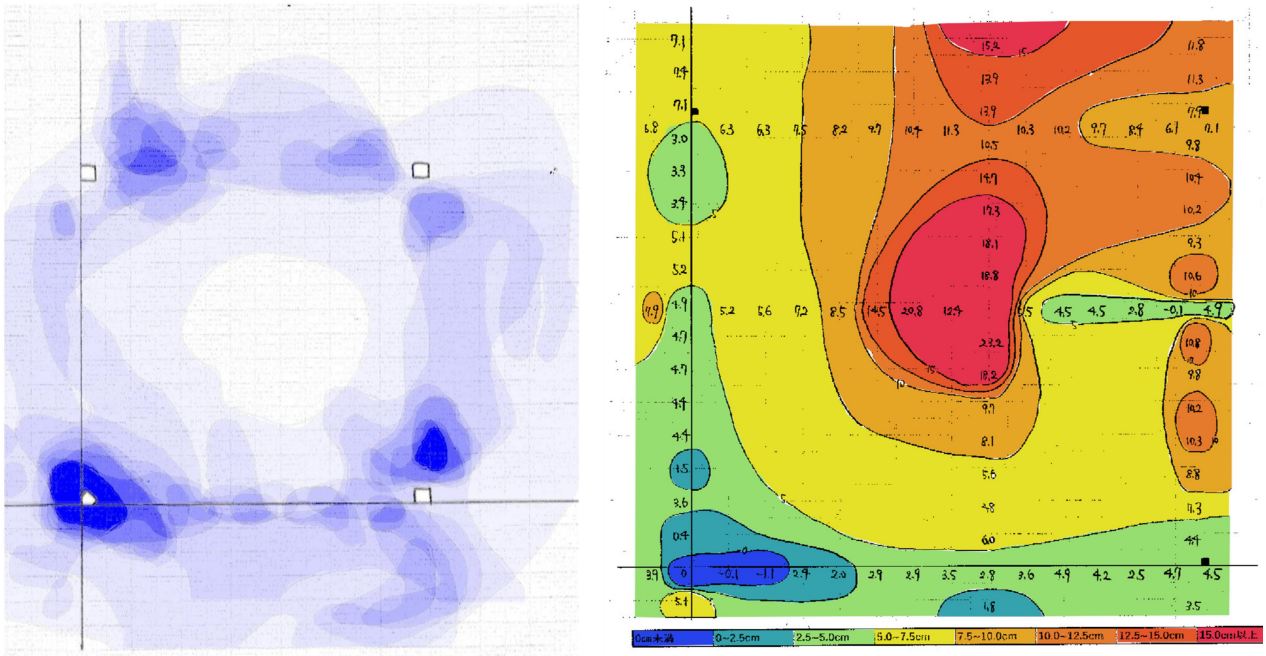
Why Is the Baseball Ground in Our School Badly Drained ?

*Ryou Ito[1], *Shuta Aoshima[1], *Tomoya Mizutani[1], *Daichi Ishii[1], Yosuke Saito[1]

1. Tokyo Gakugei University Senior High School

Tokyo Gakugei University High School Baseball Club, are regularly active on the baseball ground, have been bothered by the badness of the drainage. This research aimed to clarify why the drainage of the baseball ground is bad. Previous study in our school had three experiments: 1) observation of baseball ground after raining, 2) experiment comparing the particle size of the soil on the baseball ground and the soccer ground, 3) experiment surveying the property of underground soil with soil boring auger. It indicated that the surface drainage was the main reason of the badness of the baseball ground.
This study had the three experiments below: 1) observations of the puddles, 2) making the surface irregularity map, and 3) surveying the underground soil by soil boring auger. From these experiments, this study suggests that the main reason of the badness of drainage on the baseball ground is the flow path stagnating. For the improvement of the drainage, it is effective to continue the flow path with outside the baseball ground.
On the other hand, it was not possible to estimate the amount of the rainwater that infiltrated the baseball ground. From now on, it is necessary to survey the amount of rainwater infiltrating underground and moving on the surface in order to understand the whole movement of rainwater received by the baseball ground.

Keywords: the movement of water , surface drainage



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Spectroscopic observations of Geminids with video cameras and diffraction grating

Yuzaburo Takamura[1], *Momoo Hayashi[1], Moeka Yamagishi[1], Keisuke Nobutoki[1], Yuna Buma[1], Fuyuno Anpuku[1]

1. Ichinomiya High School

From December 2018 to January 2019, we conducted a spectroscopic observation of meteors by using a diffreaction grating attached to a camera.We collected data of Giminids meteors and identified each line spectrum.Then, we compared data of the identified molecules and atoms with the parent bodies.In addition, we analysed how the hight of the meteor effected the value of each spectrum.

Keywords: meteors, spectrum

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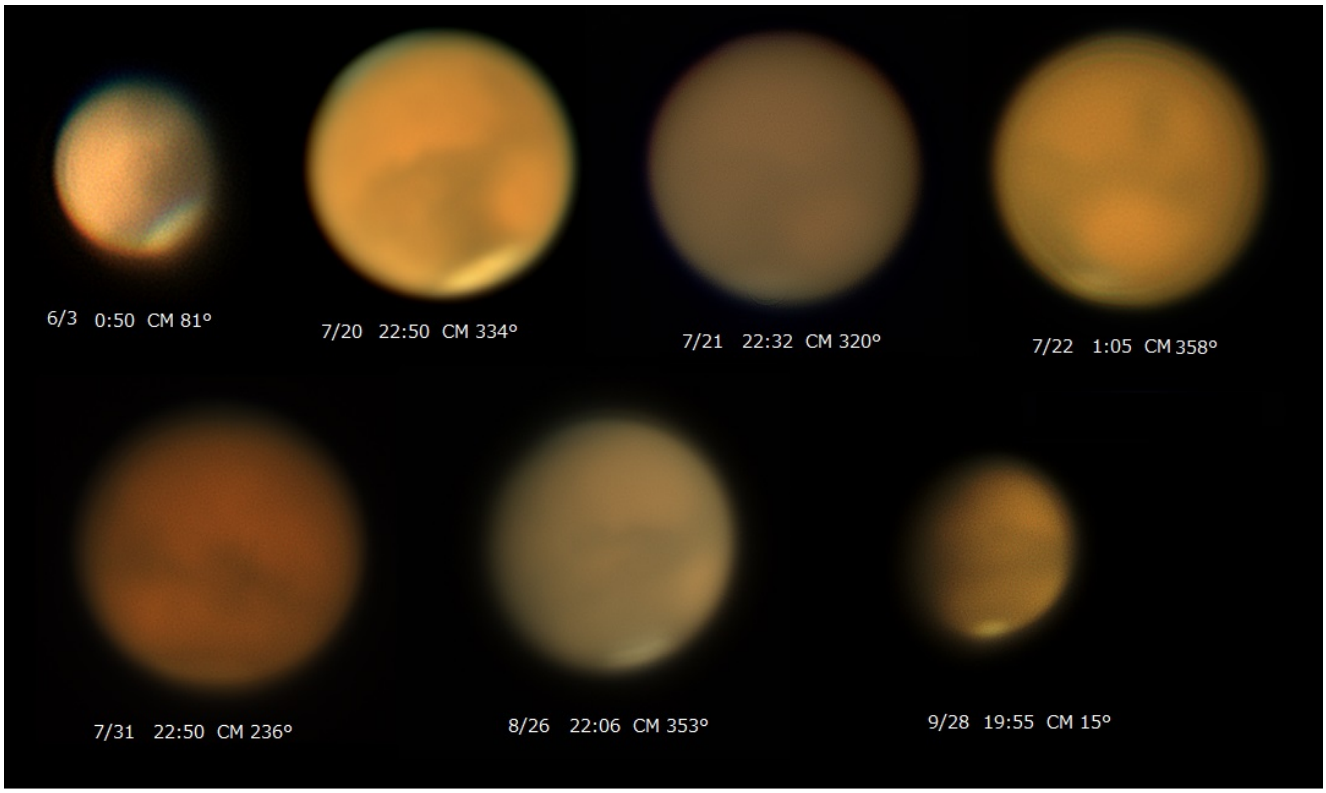
Observation of the dust storm over the polar cap of Mars

Yuzaburo Takamura[1], *Rino Hayakawa[1], Soma Ohashi[1], Yuna Kuriki[1]

1. Ichinomiya High School

With Mars Closest Approach occurred on July 31, 2018, we have observed Mars on a continuous basis using a CMOS camera. Along with this event, a massive dust storm was seen on the surface of Mars. Therefore, we analyzed how the dust storm effected our data of Mars, focusing on the polar cap. The results showed that the contrast difference throughout the polar cap got smaller as the dust storm grew big.

Keywords: the polar cap of Mars, CMOS camera, the dust storm



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Analyzing the shape of (51)Nemausa

*Taiga Hirozawa[1], Suguru Okada[1], Tomoki Suzuki[1], Tomohiro Shibayama[1]

1. Ichinomiya High School

On, April 1, 2018, we observed a star occultation of asteroid (51) Nemausa. From the collected data and the date from other observation points, we estimated the cross sectional view of Nemausa. We’ ve also conducted a photometric observation to calculate Nemausa’ s rotation period. From the two results, we estimated the possible shape of Nemausa. In addition, we compared the light curve of the actual data with the light curve of a model of the estimated shape.

Keywords: asteroid, photometric observation

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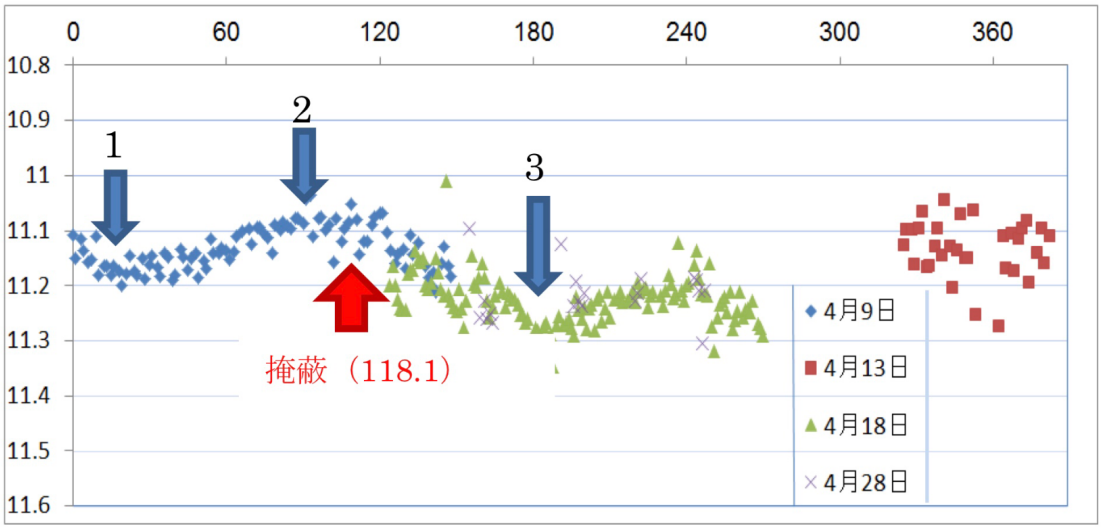
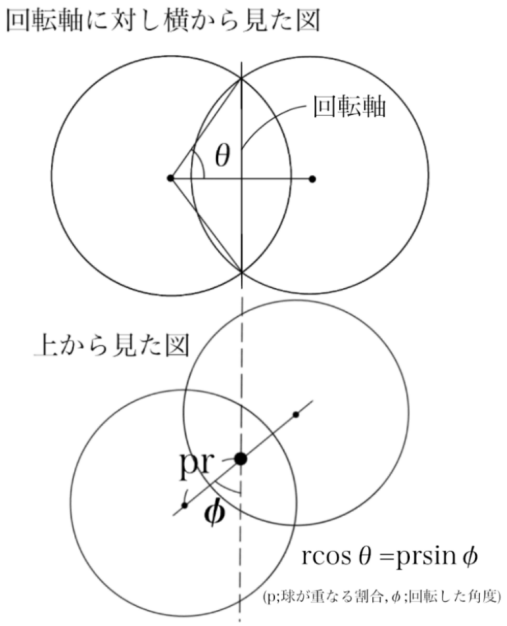
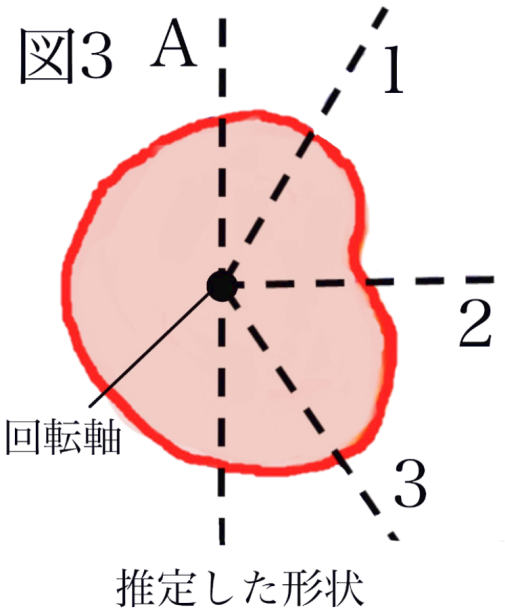


図1:観測したライトカーブ（縦軸：等級、横軸：分）

図2





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Characteristics of lightning discharge that generated sprites

Kazuki KOJIMA[1], Nanami INOUCHI[1], *Misa NAKASUJI[1], *Yasumichi NAKAHAMA[1]

1. Kagawa Prefectural Sambommatsu High School

We have been observing sprites that occur in the Hokuriku region since 2007. We have observed the sound of lightning using an IC recorder in Fukui city from 2018. We guessed the discharge path from this sound. And we considered the mechanism of sprite generation.

Keywords: sprite, thunder

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Get closer to the mustery of Sprites and Elves.

*Ayumu Nishihara[1], *Shogo Kawamura[1], *Hidetoshi Oka[1], Daichi Iriki[1], Shunsuke Nakao[1]

1. Prefectural Kochi Ozu High School

We have been researching Transient Luminous Events such as sprites and elves. Transient Luminous Events are luminescence phenomena that occur with lightning in the mesosphere at an altitude of about 50 to 100 km, and include sprites and elves. Elves is a donut-shaped light emission phenomenon that occurs around an altitude of about 100 km. It is said that the frequency of occurrence is higher than that of sprites, but even in Transient Luminous Events, the duration of light emission is as short as 1 millisecond or less, so the number of data that we can actually observe is smaller than that in sprites. In addition, since the light emission time is short, the number of frames of the camera does not match, and in many cases the peak of brightness does not appear, so many Elves images are unclear. We are collaborating with 32 high schools across the country. This is the world's largest Transient Luminous Events observation team, and holds many data. This time, we analyzed and considered using data taken at our school and data taken at a joint observation school.
This time we did research on sprites and the mystery of Elves. Sprites are a phenomenon of light emission from electrons that have lost their place due to lightning strikes, so it is natural that they occur just above lightning strikes, but there is an unnatural point of about 50 km away from the lightning strike point, and the reason is unknown . Therefore, we identified locations of sprites, elves, lightning strike points for events with very low shooting frequency, where elves and sprites occur simultaneously, and observe simultaneously at multiple schools, and consider their positional relationships.
In addition, it is known that the electromagnetic pulse that causes Elves is generated by the time change of the current intensity, is strongest at a right angle to the current, and emits light by moving the electrons in the sky. However, it is often the case that the lightning strike point and the center of Elves are separated, and the reason is not known. Therefore, it is assumed that the lightning that generates Elves extends horizontally for several kilometers in the cloud and then strikes directly under it, and it is thought that it is impossible to deduce the shape and location of Elves from the intensity distribution of electromagnetic waves emitted from the horizontally extended current. The experiment was performed using a simplified model.

Keywords: TLEs, Lightning

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Prediction of the giant-squid movement around Japan using the dataset of ocean current and temperature.

*Yuka Koike[1]

1. Hiroo Gakuen Senior High School

The giant squid is one of the largest invertebrates in the world and is believed to mainly inhabit at depths of 650m to 900m. In Japan, they have been identified mainly in the areas around the Ogasawara Islands and near the Sea of Japan. However, because they are extremely rare in the number of individuals discovered, detailed studies on behavior and distribution have not been conducted. Their migration path/habitat distribution is roughly predicted with the data of the place where the giant squids were discovered, but the quantitative analysis has not been carried out.

The purpose of this study is to identify their movement routes and ecological distribution based on topographical data and to predict them more quantitatively than the research conducted in the past. The final goal is to establish a systematic method that can predict the behavior and distribution of organisms that are not currently studied, regardless of the species.

In this research, I will conduct research from the following two directions.

First, I compare the data of the ocean current and temperature with the location of the discovery and analyze the route and distribution from multiple planes. This time, using the Google Earth Engine (hereinafter referred to as GEE), the ocean current and ocean temperature data obtained from satellites are mapped on the map and compared with the data of the discovery location. As the data of the discovery place of the giant squid, the coordinate data at the time when they were discovered in extraordinary numbers in the Sea of Japan from January 2014 to March 2015 is used[1]. The data of the discovery place is visualized using Google My Map. In the previous researches, I made global predictions using surface data for all currents and temperatures, taking the variation in depth of each data collection location into consideration. The ocean current data was replaced with the HSV color space, and the hue represents the direction of the ocean current and the lightness represents the velocity of the ocean current. As a result, 57 individuals were found in the region where the velocity of the current is almost zero or slow. As for the seawater temperature, 48 out of 57 individuals were found in the region where the seawater temperature is relatively low. The following two were considered from these results. First of all, Squid is present in the region where the ocean current is slow in order to reduce energy consumption in the deep sea where the food is extremely low. Second, it was discovered that it had surfaced to a surface with a relatively large amount of biomass compared to the deep layer. However, because the operation of GEE was insufficient, the quantitative prediction could not be made. So, this time, I will collect data at each point using the method of acquiring the velocity of the ocean current and the temperature of the ocean at each point. The results obtained will be compared with the global forecasts made in previous studies to make new quantitative forecasts.

Secondly, based on the data of the ocean current and the temperatures well as hydrodynamics, I quantitatively forecast the migration path and habitat distribution of the giant squid. At present, the goal is to calculate and visualize the current flow. For this purpose, I’ m investigating how the Boltzmann equation that describes the microscopic behavior of fluid and the Navier-Stokes equation that describes macroscopically, correspond. The Navier-Stokes equation is a basic equation of fluid. Since the solution

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of the Navier-Stokes equation does not indicate the existence, the correctness of the numerical solution obtained by performing the numerical simulation cannot be confirmed. I think that it is enough to use the differential equation obtained by discretizing in this scale. Finally, these are used to quantitatively predict how the giant squid will move from the location of the discovery.

By applying this research, it becomes possible to establish models of migration pathways and habitat distribution of not only the giant squid but also other creatures whose habitats are unknown, and it can be expected to be used for fishery and research.

References:
[1]Extraordinary numbers of giant squid, Architeuthis dux, encountered in Japanese coastal waters of the Sea of Japan from January 2014 to March 2015

Keywords: Meteorology, Oceanography

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 106 1F

[O-04] New earth and planetary science education created by hybrid community between society and JpGU

convener:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University),
Chairperson:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki AKIMOTO(Dokkyo University)

In 2017, the curriculum guidelines for elementary and junior high school were announced by the Ministry of Education, Culture, Sports, Science and Technology. In addition high school curriculum guidelines were announced in 2018.
 These guidelines show "What we learn for (goals and contents of subjects and courses)" and "How to learn (improvement of learning course)" in order to foster student qualities and abilities.
 They also highlight how to develop a curriculum which is open to society and share the common understanding of "fostering of student qualities and abilities".
 Furthermore, High School/University Articulation Reforms will be regarded as important to considering the contents of university education and the admissions so that the results at elementary and secondary education are carried over to university education, and academic ability is reliably fostered.
 Earth and planetary science education also needs to clarify "what we learn for" and respond to what society demands, proposing inquiry activities through observation and experiments in the learning process.
 This session aims to deepen understanding about expectations for new earth and planetary science education and issues to be solved by participants from various viewpoints, including teachers, researchers, students, and citizens.

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[O04-01] In the next Course of Study, let's send information on world standard "geography / geography" from Japan to the world

★Invited Papers

*YOJI TAKIKAWA[1] (1.NPO Association of Science Curriculum Initiative NPO Galileo Science Workshop)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[O04-02] What a mantle scientist hopes geoscience education

★Invited Papers

*Natsue Abe[1] (1.R&D Center for Ocean Drilling Science Japan Agency for Marine-Earth Science and Technology)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[O04-03] New high-school compulsory subject “General Geography” and related cooperation of geographers and earth scientists for human resource development

★Invited Papers

*Takashi Oguchi[1] (1.Center for Spatial Information Science, The University of Tokyo)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[O04-04] Visualization of terrain by Red Relief Image Map(RRIM) and geoscience education

★Invited Papers

*Tatsuro Chiba[1] (1.Asia Air Survey Co., Ltd.)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

Discussion

In the next Course of Study, let's send information on world standard "geography / geography" from Japan to the world

*YOJI TAKIKAWA[1]

1. NPO Association of Science Curriculum Initiative NPO Galileo Science Workshop

Previously, at the science education research meeting, a high school geology teacher introduced that "photographs before and after the earthquake" taken in his area, "predicting the dangerous place" is used for his lessons . I learned that we can predict where danger is.
Another geological teacher went to see the principal who invited me to come to my high school and said he refused "I do not want to work for a dangerous school in such a lowland". It might seem like a strange teacher at the present time, but I think that [the crisis management of Japan with many earthquakes] was quite different if these knowledge became common sense of citizens. It is also understood from this that learning of "Earth science education - natural geography, geology, mineralogy, geophysics, oceanography, meteorology etc" is indispensable for earthquake, disaster prevention, environmental understanding. However, teachers of earth science are currently endangered species in Japan. In this situation I hear that it may be forced to withdraw from the forefront of geoscience education.

On the other hand, the New Course of Study guarantees importance on "subjective, interactive and deep learning (active / learning)", not only knowledge but also "student’ s inquire” is claimed to be valued . This direction is also common to "PISA test of OECD, National curriculum of the UK, Standard NGSS of science education of the USA, etc." In short, it is considered important to acquire the "motivation, method, and the living knowledge on which it is based" necessary for the child to continue learning throughout his life. For this reason, the Ministry of Education, Culture, Sports, Science and Technology is also changing the way "college entrance examinations are implemented", especially for high schools and universities to change the direction of learning from "knowledge injection type education".

In the era when "birthrate aging and declining birthrate" and "IT" are rapidly changing the society, we are approaching a milestone that we have to reveal "content and method of education" to foster children appropriate for the next era in a fairly rapid manner. In "Geography / geography education", it is necessary to reconsider the significance of "what to teach" again. And it is time to re-send "geography / geography education" from Japan to the world. I hope everyone will work in a meaningful direction.

Keywords: New Course of Study, Active learning, Inquiry activities, Reform of entrance exam from high school to university, STEM education, The era of "low birthrate and aging" and "IT"

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What a mantle scientist hopes geoscience education

*Natsue Abe[1]

1. R&D Center for Ocean Drilling Science Japan Agency for Marine-Earth Science and Technology

When asking what kind of images you have about the Earth's mantle, most people answer "molten magma". People are probably influenced by movies broadcasting on TV, novels such as "Journey to the center of the earth by Jules Verne" and "Japan Sinks by Sakyo Komatsu", or many movies (such as Center of the earth) are strongly influenced. In general, people seem to think as follows. Because there is a hot substance deep under the ground, the "mantle" under the crust is a melted magma, and thinking that the liquid that reached the surface with some meter will erupt as lava It seems to be. I heard a conversation in the Kanto region and was shocked. Since the aftershock of the Great East Japan Earthquake on March 11, 2011, the aftershocks occurred quite a lot, "the Japanese archipelago became loose and decided to sink into the melted" mantle = (magma, but this is wrong!) " There was a person who was threatened by the fear of sinking into the lava. We geoscientists know the Japanese archipelago will never sink into the mantle in that short time-scale and never disappear our life time. Just having this basic knowledge, we are not trapped such fear, and probably know better how to deal with natural disasters such as earthquakes than general people. I think we earth scientists need to act and prepare for natural disasters as a norm for the general public. In this presentation, I would like to talk about some examples cited from my lecture and outreach experience.

As a mantle petrologist who study mantle peridotite, I strongly expect "geoscience classes" in junior high and high school that students learn basic knowledge to be able to properly fear natural disasters and prepare for it. Not only the students who are currently taking "Basic Earth Sciences", but also students entering the Department of Science other than those who wish to enter the Department of Earth Sciences at least as living in Japan, I hope that you will learn the knowledge of Geoscience literacy as a compulsory subject in high school. Contents that are covered within the scope of the current high school "basic earth science" is sufficient, broadly "scientific literacy" is needed for thinking deeply and act properly when something happens.

Keywords: geoscience education, mantle

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New high-school compulsory subject “General Geography” and related cooperation of geographers and earth scientists for human resource development

*Takashi Oguchi[1]

1. Center for Spatial Information Science, The University of Tokyo

In Japanese senior high schools, a new subject “General Geography” will be compulsory from the 2022 fiscal year. Although this subject belongs to a section of social sciences under the official education system, it puts emphasis on some physical sides of geosciences such as natural hazards, global environmental problems, and applications of digital data using GIS. Therefore, the new subject will contribute to education and human resource development in not only geography but also broader geosciences. To facilitate this, geographers and geoscientists belonging to the Japan Geoscience Union as well as some committees and subcommittees of Science Council of Japan should cooperate, as is the case with a recently established SCJ subcommittee for high-school education in geosciences and geography.

Keywords: General Geography, Geosciences, High-school education, Science Council of Japan

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Visualization of terrain by Red Relief Image Map(RRIM) and geoscience education

*Tatsuro Chiba[1]

1. Asia Air Survey Co., Ltd.

1.Introduction

Three-dimensional understanding of terrain in geoscience education is fundamental and important. For that, the reading of contour lines is a big problem. The contour line shows the planar position of the line of intersection between the topography and the plane as a representation method of the terrain. By altering the altitude at equal intervals, it is visualized as a striped pattern. In principle, horizontal and vertical planes can't be visualized. It is possible to objectively express the topography without individual skill. It is possible to transform mesh data, which is a wonderful invention. This skill is indispensable in order to read topography such as topography map of the GSI.

2. Numerical terrain data and terrain representation

Digitization of terrain had gradually become advanced since the 1980s. The national land numerical information started at 250 m, 50 m, 10 m, 5m. On the other hand, the technology for visualizing this method has remained around the time of low data density, there is no change, and the problem that detailed data can't be fully expressed can also be raised. It was difficult to read all the data in the shadow map, the gradient map, the advanced gradation diagram, and the like. Shaded figures had problems such as irregularities reversed depending on the light source direction, and there was a problem that it was impossible to distinguish between steps and grooves.

3. Principle and advancedness of RRIM

Chiba invented RRIM triggered by the topography survey of the Aokigahara ocean in Mt. Fuji in 2002. This was to visualize detailed data of a 1 m mesh by aerial laser measurement and complex topography of the lava surface where the irregularities are distributed complicatedly and to capture a large topography. The expression that it is redder as steep slope, brighter as a ridge and darker as a valley has the feature that it can be understood immediately even by ordinary people who do not receive special training and education. In addition, this figure could be overlapped with conventional contour diagrams, overlapped with advanced steps, and the understanding of the topography was greatly promoted. In many cases, it is used in media such as BURATAMORI, and recently it has become possible to select it as one of the backgrounds in geological map NAVI and GSI map.

4. JPGU and RRIM

In Asia Air Survey, as a place to transmit the goodness of the red 3D map, I regarded the exhibition of JPGU as a very good opportunity and have held a booth exhibition every year. For the first time here, some high school students also saw the red stereoscopic maps as an opportunity to be interested in topography and geology. It also leads to a series of work with JAMSTEC based on the idea that the exhibition here can be applied to the ocean bottom topography, and its submarine topographical map is bringing the further effect of geoscience education. Also, analog model experiments that flow shampoo lava on the topographical model of red 3D map repeated every year was very effective for understanding the hazard map. I would like to continue exploring what I can do for geoscience education through the activities of JPGU.

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Keywords: RRIM, hazardmap, education of earth science

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Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 106 1F

[O-04] New earth and planetary science education created by hybrid community between society and JpGU

convener:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki Akimoto(Faculty of Economics,Dokkyo University), Chairperson:Yasushi Fujiwara(Evening Classes; Integrated Course, Kanagawa Prefectual Mukainooka Technical High School), Hiroaki AKIMOTO(Dokkyo University)

In 2017, the curriculum guidelines for elementary and junior high school were announced by the Ministry of Education, Culture, Sports, Science and Technology. In addition high school curriculum guidelines were announced in 2018.
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 This session aims to deepen understanding about expectations for new earth and planetary science education and issues to be solved by participants from various viewpoints, including teachers, researchers, students, and citizens.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[O04-05] A lesson plan using Tsunami to cultivate the ability to think critically about a subject based on the data given in New government curriculum guidelines for "Basic Earth Science"

★Invited Papers

*Kodama Hidefumi[1] (1.Chiba Prefectural Matudokokusai High School)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[O04-06] The planning of “Integrated Geography” and its aimed competency

★Invited Papers

*Yasutaka Kogawa[1] (1.Okayama Prefectural Tsuyama High School)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[O04-07] Earth and planetary science education considered by the current student

★Invited Papers

*Hideto Otsuka[1] (1.Geology Course, Department of Science, Faculty of Science, Shinshu University, National University Corporation)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[O04-08] Invitation to Geography —Relationship Between Geography and Intellectual Curiosity in Daily Life−

★Invited Papers

*Takuya Miyao[1] (1.Master Program in Education, University of Tsukuba)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[O04-09] Let's build a bridge between "Rika" and society with new geography and geology education in class

★Invited Papers

*Naoki Hosaka[1] (1.science writer)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

Discussion

A lesson plan using Tsunami to cultivate the ability to think critically about a subject based on the data given in New government curriculum guidelines for "Basic Earth Science"

*Kodama Hidefumi[1]

1. Chiba Prefectural Matudokokusai High School

New government curriculum guidelines for "Basic Earth Science" show cultivating the ability to think scientifically based on the data, in addition to observation, experiments.

I will compare New "Basic Earth Science" for current one and present a lesson plan using Tsunami for cultivating the ability to think scientifically.

Keywords: New government curriculum guidelines, Tsunami

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The planning of “Integrated Geography” and its aimed competency

*Yasutaka Kogawa[1]

1. Okayama Prefectural Tsuyama High School

The next curriculum guidelines were announced in March 2018, and “Integrated Geography” of required subject is provided as the new subject of geography for “sustainable society”. On International Charter on Geographic Education, five main concepts are “Location and Distribution”, “Place”, ”People-Environment Relationships”, ”Spatial Interaction”, ”Region”. These concepts are one of the guideline on constitution of geographical curriculum, and through International Geography Olympiad, International standard such as thought and skill which is cultivated in geographical education is indicated to high school students in all over the world.
To the implementation of “Integrated Geography”, what we are going to consider when we plan the class. As the point of view, based on the test of International Geography Olympiad and the present condition of the geographical perspective and thinking skill of student in Japan, this presentation introduce The planning of “Integrated Geography” and its aimed competency.

Keywords: integrated geography, Education for Sustainable Development, International Geography Olympiad

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Earth and planetary science education considered by the current student

*Hideto Otsuka[1]

1. Geology Course, Department of Science, Faculty of Science, Shinshu University, National University Corporation

It is necessary that Earth science and geography education for elementary and high school arranges the opportunity to touch the real things. In elementary school, there are many classes to touch the real things, but in high school, we don't have enough time to explain with them. I think that education with using the real thing, understanding of the learning purpose of the student, and knowledge of teacher to answer student's questions.
At first, the earth and planetary science needs to use the knowledge not only sciense but also various information. The students are good at considering and discussion with the real things, but it is difficult to understand conceptually field. So, we should present the real things to the students.
Secondly, it is necessary to understand a learning purpose so that a student is interested. The students like to study outdoor, and understand that studying the earth science contribute to thier lives, such as disaster prevention.
Thirdly, it is important to have the ability that teachers assist for the students to practice deep learning. It is necessary that teachers answer their questions, and lead them to understand.
From these, I think that we should teach earth and planet science practically and more clearly. It is improvement of the individual ability of the teacher to be important above all. Even if it is difficult to become the expert of all fields of earth science, the geography, it is important to deepen the knowledge. It is good for an opportunity attracting the interest of the student to teach the state-of-the-art study and common sense. I hope that practically and developmental earth and planetary science education become popular in the future.

Keywords: earth and planetary science education

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Invitation to Geography —Relationship Between Geography and Intellectual Curiosity in Daily Life–

*Takuya Miyao[1]

1. Master Program in Education, University of Tsukuba

I received geography education in school, learned geography at university, and now I’ m studying geography education in graduate school. In such a position, I’ d like to mention the abilities and various perspectives obtained from that looking back on myself that has been studying geography. Specific details are as follows.

Why Am I fascinated to Geography?

I’ ve been faced to the subject of geography, so what is the trigger that I was interested in geography? I’ d like to mention about the opportunity that I was involved in geography through reconsidering myself.

Relations Between Everyday Life and the Viewpoint That Can Get by Learning Geography, Application to Geography

Academic geography is close to our everyday life. It is because geography is a discipline that deal with an actual proof, and especially, the contents we learn from junior high school or high school have many things applying to information and experience we see in our daily life. So, what is the competency that acquired from learning geography? The typical one is “geographic viewpoint and way of thinking.” Then, if we acquire that competency, what are the benefits in daily life? I hope to mention based on my experience and the idea of graduate students who have been on the same situation.
On the other hand, the core point of view of the new geography course in Japanese high school, such as “GIS,” “international Understanding,” “disaster prevention,” there is no doubt that these contents are related to our living area when thinking on the micro scale. For students to learn geography actively, it may be necessary to incorporate contents that make use of students’ knowledge and experiences into the introduction of lessons. I suppose that this is the same in earth science.

About Learning Geography at University and Graduate School

In this part, I would like to mention about two things. One is about university education. It is often said that “geography is memorized subject,” but I strongly feel that was the lecture I took in a university. In teaching subjects, it is desirable to have opportunities for teachers and students to exchange opinions on the contents and methods of classes making full use of the characteristics of geography.
The other is about university and graduate school education. There are few opportunities for learning collaborated in geography, history and civics. It is necessary to exchange opinions among these subjects because these are not independent subjects, and there are many parts that work mutually.

Keywords: Geography Education , Geographic View and Way of Thinking, Intellectual Curiosity

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Let's build a bridge between "Rika" and society with new geography and geology education in class

*Naoki Hosaka[1]

1. science writer

Science does not seem to work well when it comes to the consensus formation of modern society, such as global warming. It can be due to the lack of reality of science, although it closely related to the social agenda. New geography and geology education should be a bridge between science and society.

Keywords: science, society, global

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Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 101 1F

[O-05] English improvement tips for Japanese scientists

convener:Chisato Yoshikawa(Japan Agency for Marine-Earth Science and Technology), Wonsuh Song(Waseda University), Rumi Ohgaito(Japan Agency for Marine-Earth Science and Technology), Chairperson:Chisato Yoshikawa(JAMSTEC), Wonsuh Song, RUMI OGAITO(JAMSTEC)

"Presentation in English" is inevitable skill not only for researchers but also for business people or students. In this session, we invite a native English-speaking researcher and a researcher of linguistic education. We learn misleading or unnatural expressions that Japanese tend to do in presentations in English. A mini-workshop is also planned in the session. In this workshop, the lecturers give advises for short presentations given by several Japanese. Why don't you join us to have practical learning to improve your presentation skill?

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[O05-01] Giving a successful presentation in English: Mission Possible!

★Invited Papers

*Joel Laurier[1] (1.University of Tsukuba)

11:05 AM - 11:25 AM JST | 2:05 AM - 2:25 AM UTC

[O05-02] How to deliver good presentations in a foreign language

★Invited Papers

*S. Lan Smith[1] (1.Marine Ecosystem Dynamics Research Group, Research Centre for Global Change, Japan Agency for Marine-Earth Science and Technology)

11:25 AM - 12:15 PM JST | 2:25 AM - 3:15 AM UTC

Discussion

Giving a successful presentation in English: Mission Possible!

*Joel Laurier[1]

1. University of Tsukuba

As with all skills, delivering a successful presentation requires painstaking effort. For people presenting in their second (or third) language, the task is even more daunting because it requires detailed attention to each spoken word. This presentation aims to help presenters of all levels, from the beginner to the seasoned expert, deliver easy to understand and effective public speeches. We will first look at common mistakes made in delivering oral presentations, then look at proposed ways to prepare and deliver quality speeches. A special emphasis will be placed on effective techniques to use in English presentations given by non-native presenters. Attendees will learn how to use body language, effective visuals, and story telling to deliver quality presentations.

Keywords: presentation skills, English speech

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How to deliver good presentations in a foreign language

*S. Lan Smith[1]

1. Marine Ecosystem Dynamics Research Group, Research Centre for Global Change, Japan Agency for Marine-Earth Science and Technology

Presenting in a foreign language, for example at international scientific meetings such as JpGU, can be an intimidating challenge. This challenge includes not only communicating one’s own ideas clearly, but also understanding and responding to critical questions, typically within only a few minutes. We researchers can all benefit from continually developing the skills to present in an engaging way that makes a good impression on the audience. To this end, I will share my thoughts based on my experiences as a native English speaker who has worked as a researcher in Japan for 20 years. I have presented results in Japanese at many seminars, conferences, hearings at funding agencies, and job interviews. Of course, no native Japanese would ever mistake me for a native speaker, as will be obvious to all attendees! But still, I have found ways to communicate effectively and have even become nearly as comfortable presenting in Japanese as in my native English. My techniques include: 1) use simple wording, clear statements, and slides that are not too complicated, 2) practice each presentation at least three times, cut out the unnecessary, and get comfortable with the flow, and 3) engage actively with questioners and ask them to clarify their questions if necessary. Accept the challenge, build up your presentation skills, and expand the possibilities for your own career!

Keywords: English, communication, career development, international, skills

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[J] Poster | O (Public)：Public

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_1

[O-06] How to cope with intensifyng storm and flood disasters

convener:Jun Matsumoto(Deaprtment of Geography, Tokyo Metropolitan University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Akira Wada(Tokyo Institute of Technology)

In the year 2018, we experienced severe rainfalls in July and severe typhoons in September in West Japan, which impressed us that severe storm and flood disasters have been intensifying. Will such severe disasters intensify in future? We will discuss how to cope with intensifying storm and flood disasters. All the oral presentations are invited talks by the specialists in the Japan Geoscience Union (JpGU), and the Japan Academic Network for Disaster Reduction (JANET-DR) which was established in 2016. We will also exhibit poster presentations of various research activities in JpGU and JANET-DR.

[O06-P01] Automatic extraction analysis of widespread sediment disasters from satellite images in the Heavy Rain Event of July 2018, Japan

*Hiroyuki Shimomura[1], Kanichiro Mochizuki[1], Tomokazu Itano[1], Atsuo Noda[1], Yasuaki Honda[1], Mayumi Miyazaki[1], Masashi Omata[1], Noriyuki Shibuya[1] (1.PASCO CORPORATION)

[O06-P02] Examination of the factors influencing the people's evacuation behaviors and cognition of reconstruction in the western Japan heavy rain disaster in July 2018

*Shoji Ohtomo[1], Reo Kimura[2] (1.Konan Women's University, 2.University of Hyogo)

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1. PASCO CORPORATION

[Introduction]The rain front and Typhoon Prapiroon caused the Heavy Rain Event of July 2018, which was a wide area heavy rain disaster in Japan, especially in its western part. Floods and sediment disasters occurred in various places and resulted in a lot of deaths and missing persons. On the occasion of these widely spread simultaneous multiple disasters, there are concerns about delay of starting the initial response. In order to identify the broadly scattered sites of sediment disasters, we applied an automatic extraction analysis using satellite images of wide area coverage.
[Status and issues of existing methods]Aerial photographs are mainly utilized for grasping damage situation in devastating disasters. A number of responsible organizations implemented the aerial photographing at the heavy rain disaster. Geospatial Information Authority of Japan created the land surface failure distribution maps based on the aerial photographs of Southern District of Hiroshima Prefecture, Uwajima Island and Ozu District of Ehime Prefecture, Iwakuni District of Yamaguchi Prefecture, acquired during 9 to 19 July [1)]. PASCO CORPORARION provided the distribution maps of sediment moving scars for the possibly-damaged areas (Kure City and others) developed from the satellite images of SPOT 7 for Hiroshima, Okayama and Ehime Prefectures during 9 to 16 July [2)]. Both results were obtained only for a part of affected areas because of limited image acquisition or analysis. Besides, even well-skilled experts need a lot of time for processing. These issues are mentioned as the problems need to be solved in the field of early response to the widespread disasters.
[Automatic extraction analysis from satellite images]The SPOT Satellites provide images with 60km swath width. In addition, their plural satellite operation endorses the revisit capacity of almost daily basis. These characteristics are superior, although the 1.5m ground resolution is inferior to 20cm of aerial photographs. Our target area of satellite image acquisition is 11,400km^2 including Okayama, Hiroshima and Ehime Prefectures. We applied the automatic extraction analysis to this area in order to identify the affected sites of sediment disasters quickly. The analysis method is based on a supervised maximum likelihood classification method, frequently used in the sphere of remote sensing image analysis. After the classification using the slope failure sites in the images as the supervised data, several sites were extracted as the possibly-affected areas. Then, the forest area data of the National Land Numerical Information was used to eliminate playgrounds or other bare lands in the urban area. The analysis results were compiled into the standard grid square (about 1km by 1km) map with color based on the occupancy area ratio of affected sites in each grid. The analysis time of the process is about one day which is shorter than human-wave tactics. However, some of small surface failure sites (e.g. narow debris flow zone) are not extracted. Past-affected sites and cutover areas are also misidentified. Although these individual issues should be treated more carefully, the density distribution map is helpful to grasp an overview of the damages.
[Conclusion]We showed the availability of the wide area satellite images to grasp an overview of sediment disasters, even in the Heavy Rain Event of July 2018 which devastated widely in Japan, although the usual aerial photograph analysis could achieve only limited areas. Because the optical satellite images of 1.5m resolution provide less clear view than aerial photographs, we will research to define the reasonable conditions to utilize satellite images for understanding of sediment disasters in details. We will also approach the development of automatic interpretation technologies using artificial intelligence in order to

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obtain further extraction accuracy, because current our method still remains several misidentified or not-extracted sites.

Keywords: Heavy Rain Event of July 2018, sediment disasters, satellite images, automatic extraction analysis

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Examination of the factors influencing the people's evacuation behaviors and cognition of reconstruction in the western Japan heavy rain disaster in July 2018

*Shoji Ohtomo[1], Reo Kimura[2]

1. Konan Women's University, 2. University of Hyogo

The torrential rain from June 28th to July 8th in 2018 caused serious human suffering and damage of property. In such natural disasters, investigation of people's evacuation behaviors at the time and the subsequent recovery process is important to consider support for the affected areas and preparedness for future natural disasters. A previous study indicated that knowledge of disaster had an effect on evacuation behaviors and the subsequent cognition of disasters (e.g. Kimura et al., 2017). This study examined the influences of residents' features in the affected areas of the western Japan heavy rain disaster in July 2018 on the evacuation behavior and the subsequent cognition of risk and of recovery from the disaster.

We implemented a web survey study for 1000 residents in 13 districts in Hiroshima prefecture and 6 districts in Okayama prefecture where that suffered damage caused by the western Japan heavy rain disaster in July 2018. Figure 1a shows the framework of the web survey. The survey asked about the demographic information related to the disaster, damage situations, cognition of disaster risk, recovery and reconstruction calendar and so on. The study analyzed the relationships between residents' prediction for flood damage, evacuation behavior, risk perception, and cognition of recovery. Main results are summarized into four. First, the relationship between prediction for flood damage and evacuation behavior was analyzed by Bayesian inference (Figure 1b). There was a difference in evacuation behavior at the time depending on the level of prediction for flood damage(b=.13, 95%CI=.01˜.25). Residents who thought that damage by flooding would not occur tended not to evacuate. Second, the relationship between knowledge about the hazard-map and evacuation behavior was analyzed by Bayesian inference (Figure 1c). Evaluation behavior at the time differed according to the level of knowledge about the hazard-map (b=.30, 95%CI=.19˜.42). The less knowledge about hazard-map, the fewer residents tended to evacuate. Third, we compared the difference in risk perception (i.e. severity) after the disaster, according to the level of damage by the western Japan heavy rain disaster (Figure 1d). Bayesian inference indicated that there was a difference in perception of the severity of heavy rain between people who had not suffered and people who have suffered from flooding above floor level(b=-.62, 95%CI=-.92˜-.32). People who had suffered above floor level perceived that they were more likely to suffer from future heavy rain than those who had not suffered. Finally, the study compared the difference in cognition of recovery according to the level of the damage by the disaster (Figure 1e). Bayesian inference indicated that there was a difference in cognition of recovery between people who had not suffered and people who had suffered from flooding above floor level (b=2.70, 95%CI=1.53˜4.38). The cognition of recovery was weaker for people who had suffered from flooding above floor level than those who were not suffered.

The study suggested that people's recognition of natural disasters beforehand affected evacuation behavior at the time of the western Japan heavy rain disaster in July 2018. Without adequate knowledge of natural disasters, people are less likely to take evacuation behavior. Furthermore, the study showed that experience suffering from the disaster influenced afterward risk perception and cognition of recovery. The experience is reflected in people's awareness of disaster. Therefore, the study suggested that the dissemination of adequate knowledge of natural disaster such as the hazard-map is important to enhance

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people's ability to cope with heavy rain disaster.

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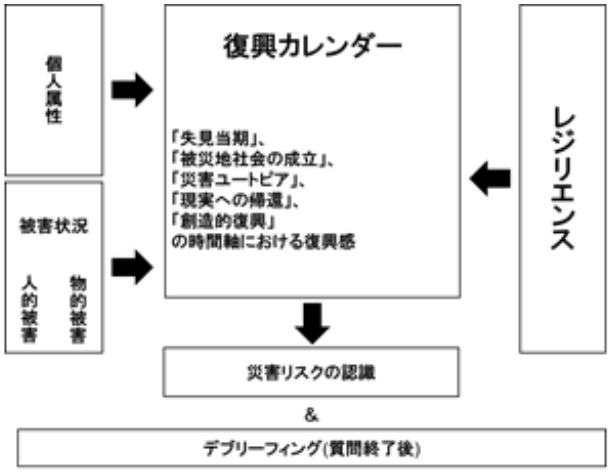

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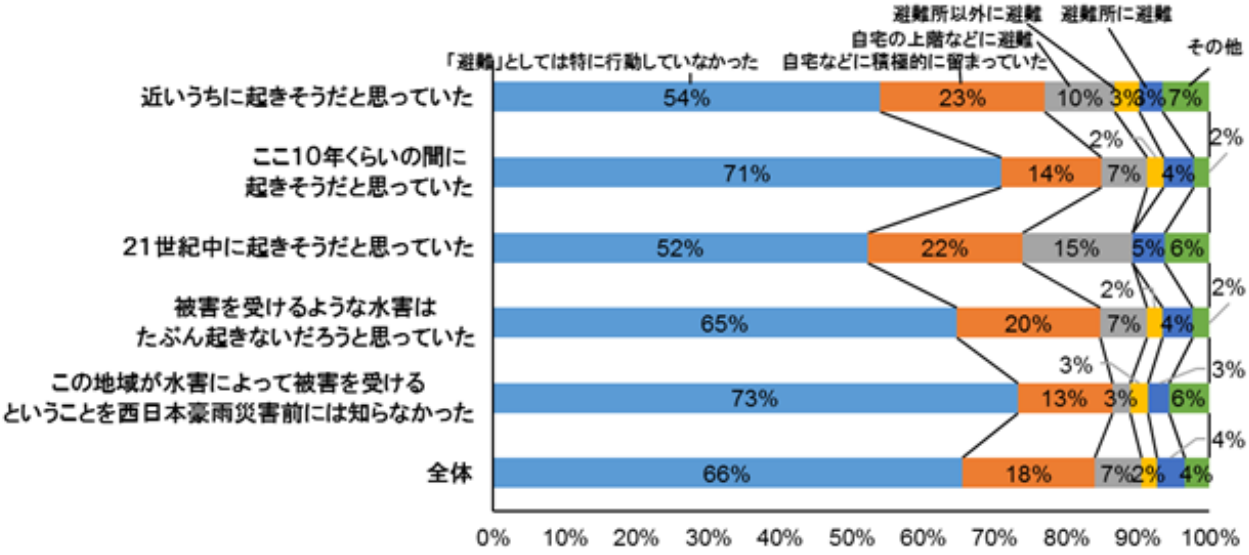


Figure 1b The cross table of prediction for flood damage by evacuation behavior

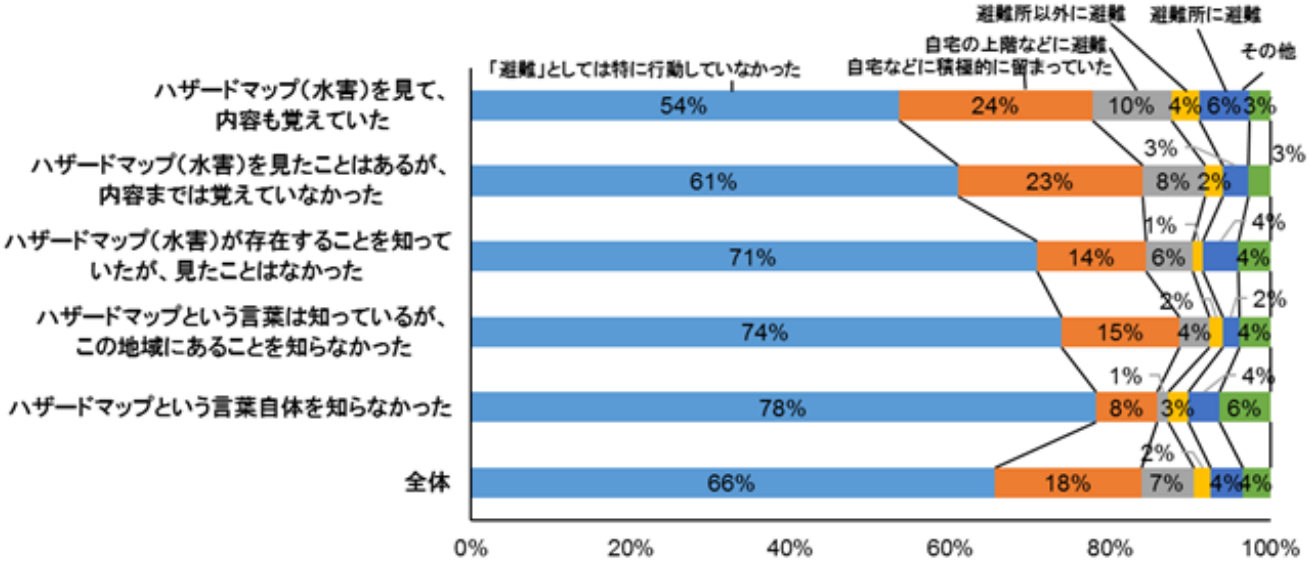
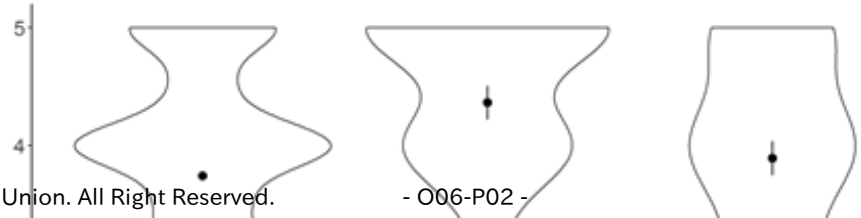


Figure 1c The cross table knowledge of hazard-map by evacuation behavior



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[J] Poster | O (Public)：Public

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_1

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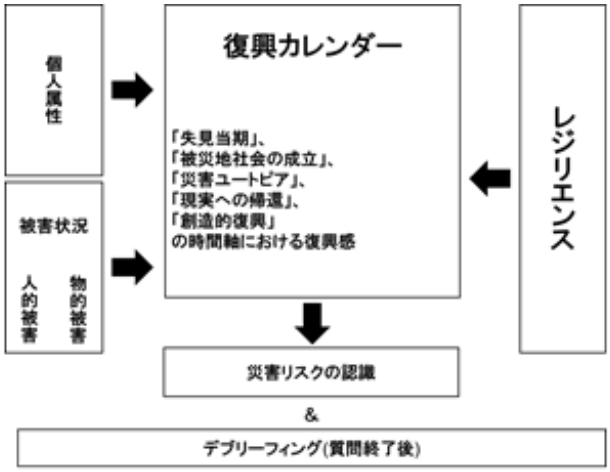

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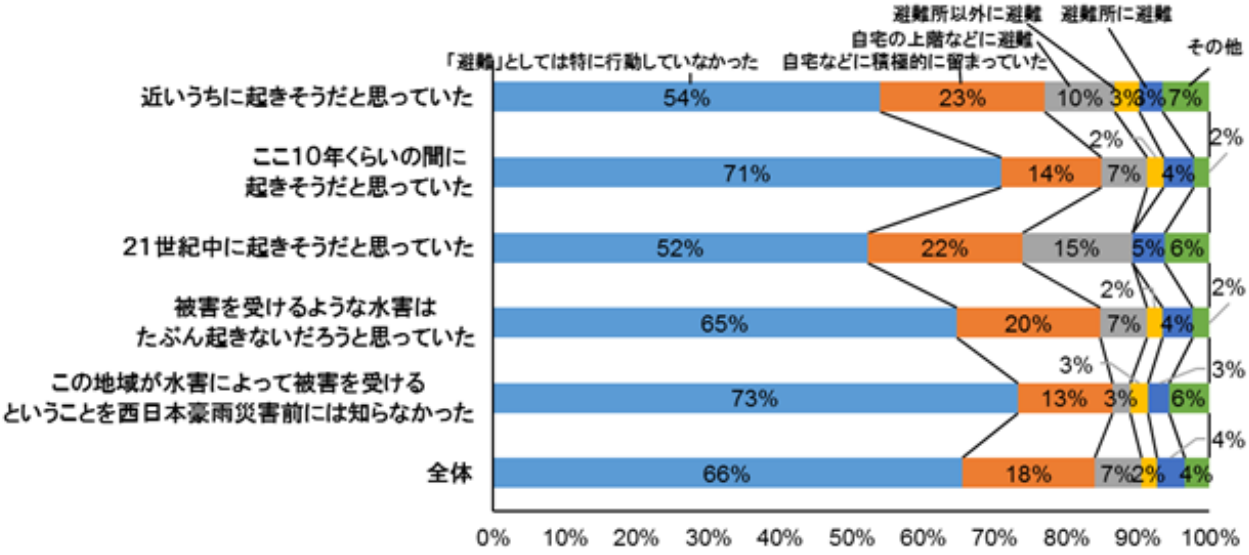

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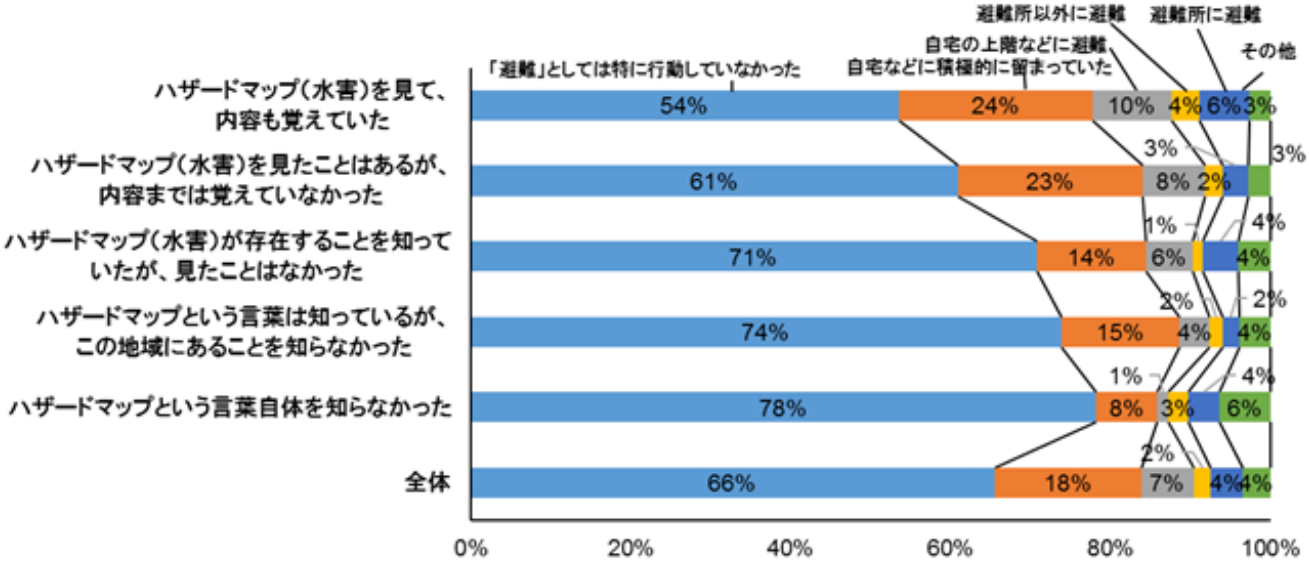

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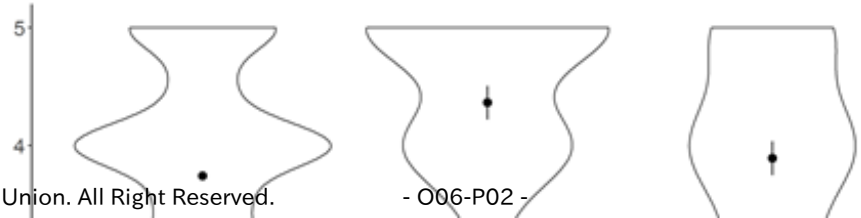

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 103 1F

[O-06] How to cope with intensifyng storm and flood disasters

convener:Jun Matsumoto(Deaprtment of Geography, Tokyo Metropolitan University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Akira Wada(Tokyo Institute of Technology), Chairperson:Jun Matsumoto(Tokyo Metropolitan University)

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1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[O06-01] Extreme rainfall and heat wave over Japan in 2018 summer: A series of extreme events and underlying global warming

★Invited Papers

*Hisashi Nakamura[1] (1.Research Center for Advanced Science and Technology, University of Tokyo)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[O06-02] **Influence of meteorological disasters on marine ecosystem**

★Invited Papers

*Yu Umezawa[1,2] (1.Tokyo University of Agriculture and Technology, 2.Study Group on Marine Environmental Problems, the Oceanographic Society of Japan)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[O06-03] Understanding of geomorphic condition indicating the flooding disaster and hazard mapping

★Invited Papers

*Yohta KUMAKI[1] (1.Senshu University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[O06-04] A role of free satellite remote sensing data as a case study of heavy rain disaster in July 2018

★Invited Papers

*Yuji Sakuno[1] (1.Graduate School of Engineering, Hiroshima University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[O06-05] State of the Crisis Mapping for heavy rain in west of Japan, 2018.

★Invited Papers

*Taichi Furuhashi[1] (1.Aoyama Gakuin University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[O06-06] A Study on Spatial and Temporal Resolution of Evacunation Infomation for Effective Evacuation Behavior

★Invited Papers

*Michinori Hatayama[1] (1.Disaster Prevention Research Institute, Kyoto University)

Extreme rainfall and heat wave over Japan in 2018 summer: A series of extreme events and underlying global warming

*Hisashi Nakamura[1]

1. Research Center for Advanced Science and Technology, University of Tokyo

In early July extreme rainfall occurred particularly over western Japan and the Tokai region, named “the Heavy Rain Event of July 2018”, which caused widespread havoc. It was followed by heat wave that persisted over most of Japan in setting the highest temperature on record in late July.
The rain event can be attributed to two extremely moist airflows from the Tropics confluent persistently into western Japan in addition to large-scale ascent along the stationary Baiu front. The heat wave is attributable to the enhanced surface North Pacific Subtropical High with a prominent barotropic anticyclonic anomaly just north of western Japan. The consecutive occurrence of these extreme events was related to persistent meandering of the upper-level subtropical jet, indicative of remote influence from the upstream. The heat wave can also be influenced by enhanced convective activity under the above-normal warmness over the tropical North Pacific. The global warming can influence not only the heat wave but also the rain event, as suggested from long-term increasing trends observed over Japan in intensity of extreme precipitation and water vapor amount. Another contribution was possible from anomalous warmth over the midlatitude Northern Hemisphere observed since March 2018.

Keywords: heavy rainfall event over western Japan in July 2018, heat wave over Japan, extreme climate events, jetstream meanders, global warming

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Influence of meteorological disasters on marine ecosystem

*Yu Umezawa[1,2]

1. Tokyo University of Agriculture and Technology, 2. Study Group on Marine Environmental Problems, the Oceanographic Society of Japan

Since the establishment in 1973, the Study Group on Marine Environmental Problems, the Oceanographic Society of Japan, has been organizing a night sessions and symposiums on marine environmental problems, and summarizing recommendations based on scientific knowledge.

In recent years, with the global warming, an increase in meteorological disasters such as typhoon, localized torrential rain and flood damages has been greatly affecting marine ecosystems, especially in coastal waters. However, our group has not done any efforts to consider weather disasters as one risk of marine environmental problems. In this presentation, I will report on previous studies on the effects of weather disasters on marine ecosystem and hope that this will be utilized in future collaborative research.

Keywords: coastal areas, marginal seas, climate change

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Understanding of geomorphic condition indicating the flooding disaster and hazard mapping

*Yohta KUMAKI[1]

1. Senshu University

It is important for the general public to know the place where the natural disaster risk is high. Some geomorphic features are strongly relating to flood or debris flow and useful for understanding the risk. For example, alluvial cone is a highly possible place of debris flow. Geomorphic features have been formed by repetitive phenomena that cause rapid landform changes, i.e. natural disasters. Therefore, it is useful for disaster estimation to know the geomorphic features. The geomorphic survey can be done everywhere at low cost using topographic maps, digital elevation models and air-photos.
The geomorphic condition has been basic information of hazard mapping. Hazard maps, however, show very much simplified information. It is desirable that people can judge the disaster risk by themselves. For it, some kinds of geomorphological maps are available in big plains in Japan.

Keywords: disaster risk, debris flow, landform change, geomorphological map

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A role of free satellite remote sensing data as a case study of heavy rain disaster in July 2018

*Yuji Sakuno[1]

1. Graduate School of Engineering, Hiroshima University

A heavy rain disaster occurred mainly in western Japan In July 2018. Immediately after the disaster, various types of aerial photographs and satellite remote sensing (RS) images were taken. In this presentation, I will introduce ground surface analysis using optical and synthetic aperture radar (SAR) in land and inland water around Hiroshima prefecture and their data roles which can be obtained free of charge, especially. It is useful to show the state of landslides and river sediment accumulation clearly by making difference image before and after the disaster using satellite optical sensors data such as LANDSAT-8 and Sentinel-2 with 10 to 30 m resolutions. However since such optical sensors are influenced by the cloud, it is not suitable for rapid damage estimation. Therefore, the difference image analysis similar to the optical sensor using SAR data such as Sentinel-1 was conducted. By this work, in particular, the flooded area was quickly extracted. In the future, we will make these tasks manual, and if any satellite data is downloaded, anyone will make software that can do the same analysis quickly. By regularly conducting data processing courses using such manual and software on local administrative agencies and consultants in construction, we would like to aim at early utilization of RS data in the event of frequent disasters.

Keywords: satellite, flood, SAR

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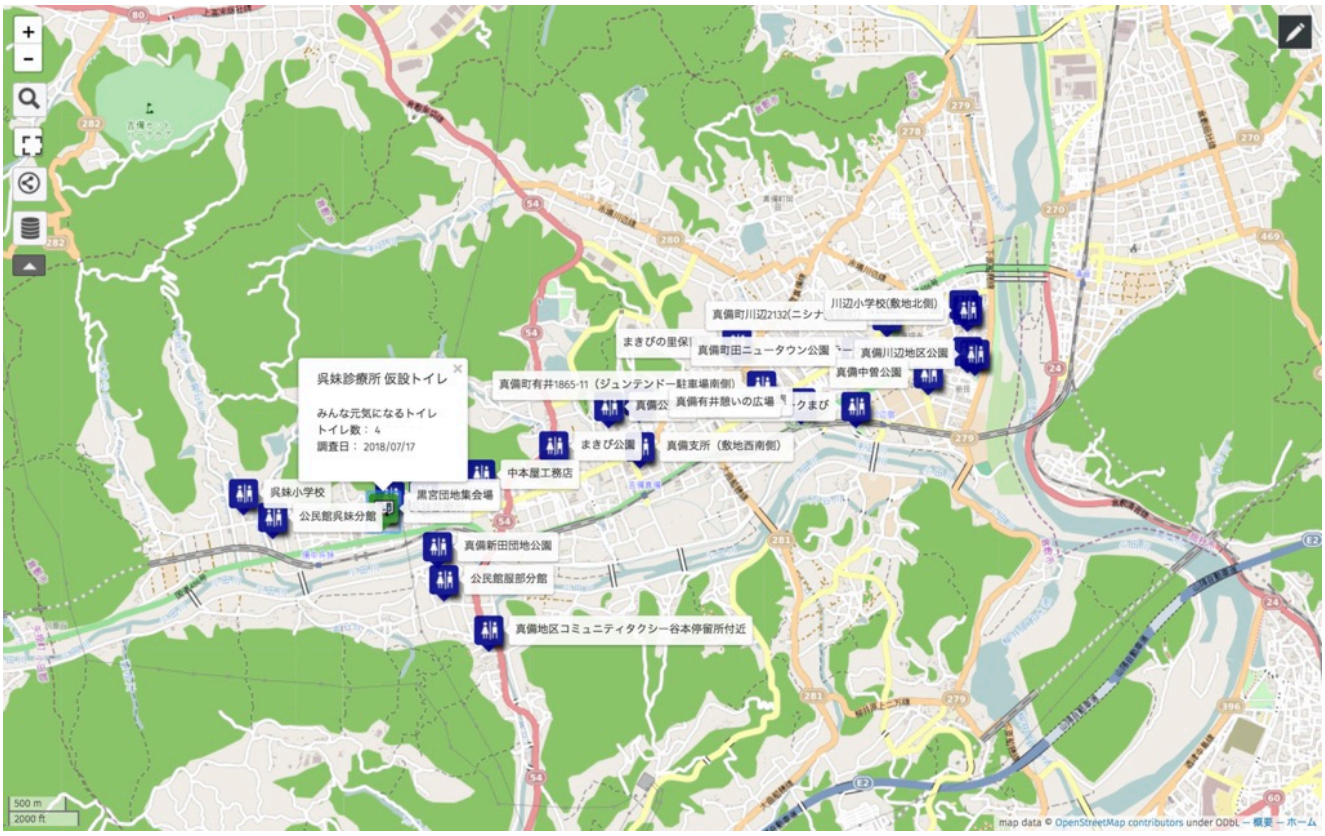
State of the Crisis Mapping for heavy rain in west of Japan, 2018.

*Taichi Furuhashi[1]

1. Aoyama Gakuin University

In early July 2018, heavy rain disasters happend in West part of Japan, floods and landslides occurred in many areas, including Mabi-cho in Kurashiki-shi, Okayama Prefecture. We worked with students on crisis mapping activities to implement maps of disaster affected areas as Volunteered Geographic Information (VGI). Specifically, navigation guide maps, evacuation centers / temporary toilets locations etc. were published on the map. In this session, we will report on current issues toward generalization of crisis mapping approach and future.

Keywords: GIS, VGI, map



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A Study on Spatial and Temporal Resolution of Evacunation Infomation for Effective Evacuation Behavior

*Michinori Hatayama[1]

1. Disaster Prevention Research Institute, Kyoto University

1. Introduction

In recent years, heavy rains and typhoons that have never been experienced in the past have attacked Japan, such as Northern Kyushu District Heavy Rain in 2017 and Heavy rain in July, 2018, due to the effects of climate change, leaving large damages in various places. In natural phenomena never experienced in the past, actions that protect lives, in other words, appropriate evacuation are required. Evacuation information that triggers evacuation is important, but in some cases, because it will create residents who don’ t take initiative for their evacuation, various discussions have been made on when and how to use and how to utilize evacuation information. In the case of the Izu Oshima Sediment disaster that occurred due to heavy rain accompanying Typhoon Wipha in 2013, the evacuation recommendation was not issued, and in Hiroshima landslide disaster caused by the Heavy Rain in August, 2014, the delay of the evacuation information was pointed out. Following these issues, the "Guidelines on evacuation advisory" was revised in the year of 2017. However, there remains room for discussion as to whether these information are linked to evacuation behaviors. In this paper, we discuss these issues.

2. Evacuation Information and Expected Behavior

In the "Guidelines on evacuation advisory", it is recommended to prepare criteria according to local circumstances about evacuation preparation, evacuation recommendation, and evacuation order from the view points of receivers. Evacuation actions were defined as follows;

(1) evacuation to the "urgent evacuation places" which are designated by administration,

(2) evacuation to the "safe place nearby", and

(3) movement to more secure room inside the building.

3. Temporal Resolution of Evacuation Information

In floods caused by heavy rain and sediment-related disasters, evacuation information will be announced in conjunction with time prediction of rainfall. In recent years, the occurrence of disasters is often expected to be late at night, but even if disaster information is announced at midnight, in many cases it cannot lead to evacuation behavior. Considering this, evacuation is proceeding from the time zone where evacuation behavior can be taken, but evacuation information in the absence of sense of crisis often leads to evacuation behavior.

4. Spatial Resolution of Evacuation Information

Evacuation information is generally presented to certain areas rather than to individual units. This spatial resolution does not have unified standards, but it varies from local governments. When the area is large,

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there are many places where high risk and low risk are mixed within the area, and many residents judge that it is not necessary to take evacuation action. However, it is difficult for the municipalities that do not allocate adequate personnel to respond to disasters, it is difficult to narrow down the areas further and it is difficult to judge whether evacuation should be made for each door.

5. Conclusion

Residents cannot be judged of evacuation behavior by evacuation information unless they know its time resolution and spatial resolution. In order to properly receive these information and to take appropriate action, it is necessary for residents to raise their awareness. In order to realize this, it is required not only to prepare administrative policies but also to arrange arrangements in the region and home.

Keywords: disaster information, evacuation behavior

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 103 1F

[O-06] How to cope with intensifyng storm and flood disasters

convener:Jun Matsumoto(Deaprtment of Geography, Tokyo Metropolitan University), Yukihiro Takahashi(Department of Cosmosciences, Graduate School of Science, Hokkaido University), Akira Wada(Tokyo Institute of Technology), Chairperson:Akira Wada(Tokyo Institute of Technology), Yukihiro Takahashi(Hokkaido University)

In the year 2018, we experienced severe rainfalls in July and severe typhoons in September in West Japan, which impressed us that severe storm and flood disasters have been intensifying. Will such severe disasters intensify in future? We will discuss how to cope with intensifying storm and flood disasters. All the oral presentations are invited talks by the specialists in the Japan Geoscience Union (JpGU), and the Japan Academic Network for Disaster Reduction (JANET-DR) which was established in 2016. We will also exhibit poster presentations of various research activities in JpGU and JANET-DR.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[O06-07] Multi-layered Countermeasures against Widespread Devastating Flood Disasters

★Invited Papers

*Koike Toshio[1] (1.International Centre for Water Hazard and Risk Management)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[O06-08] Technologies and wisdom in housings and buildings for protecting our lives from river floods

★Invited Papers

*Kazuo Tamura[1] (1.Seismic Design Laboratory)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[O06-09] State and Challenges of Disaster Waste Management - Lessons from Recent Disasters –

★Invited Papers

*Yuichi Moriguchi[1], Masahiro Osako[2] (1.Graduate School of Engineering, The University of Tokyo, 2.Center for Material Cycles and Wasre Management Research, National Institute for Environmental Studies)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[O06-10] Evacuation Planning for School Children and Community Residents

★Invited Papers

*Takeshi Sato[1], Yoshiaki Yazaki[2] (1.Tohoku University, 2.Institute of Safety Education for School Children)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[O06-11] Health Emergency and Nursing on Flood Disaster

★Invited Papers

*Sakiko Kanbara[1], Aiko Yamamoto[2] (1.University of Kochi, 2.Shitennoji University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[O06-12] General discussion

*Jun Matsumoto[1,2], Yukihiro Takahashi[3], Akira Wada[4] (1.Tokyo Metropolitan University, 2.JAMSTEC, 3.Hokkaido University, 4.Tokyo Institute of Technology)

Multi-layered Countermeasures against Widespread Devastating Flood Disasters

*Koike Toshio[1]

1. International Centre for Water Hazard and Risk Management

The largest water vapor convergence since 1958 was recorded across western Japan in early July 2018, breaking the records of 24-to-72-hour rainfall at many stations in the area and causing devastating disasters including floods due to bank breaches and overflows, debris flows, and urban inundations. We also witnessed new types of disasters induced by multiple causes including the backwater phenomenon at confluence zones and floods involving a huge scale of floodwater and sediment transport simultaneously. Furthermore, eight dams in western Japan exhausted their flood control capacities and had to start emergency water-discharge operations to avert reservoir overflows from the heavy rainfall. In addition, we later learned that dam discharge warnings were not used effectively to support residents in safe evacuation. As a consequence, 232 people either died or went missing, and prefectures in western Japan suffered significant economic damage. The number of more than 200 victims was the worst case since 1982. To prevent the recurrence of devastating disasters over a wide area, the Council for Social Infrastructure Development analyzed the characteristics and issues of the July 2018 disasters and submitted a report including the recommended countermeasures based on the key strategies to the Minister of Land, Infrastructure, Transport and Tourism on December 13, 2018. Towards building a community where everyone evacuates proactively, the report recommends that each community develop a cooperative framework to strengthen self-help and mutual support by enriching information of hazards, risks and evacuation and improving communication methods in cooperation with the mass media and the ICT private sector. The report also proposes more resilient infrastructure design, development and operation against complex disasters and hazards which exceed infrastructure capacities and suggests strategies for the implementation of quick disaster responses and recoveries and extra considerations of disaster risks in community development. We need to promote such multi-layered countermeasures as a package to cope with unprecedented disasters.

Keywords: flood, debris flows, backwater, emergency water-discharge operations to avert reservoir overflows

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Technologies and wisdom in housings and buildings for protecting our lives from river floods

*Kazuo Tamura[1]

1. Seismic Design Laboratory

There exist many areas which have high risk of flood damages in Japan. River dykes or dams have been constructed to suppress flood damages. However, these countermeasures are not enough, in the condition that severe meteorological phenomena with heavy rainfalls become more frequent. We should make use of technologies and wisdom or ideas in the field of buildings to protect our lives or to maintain our living environment. The river management of the whole river basin, with planning the houses or buildings of the area, is necessary against these severe conditions.

In this presentation, the author explains current situation and applicable technologies of building structures, focusing on maintaining safety of our lives against river floods.
For example, raising the ground level of the building is one selection for the countermeasure against floods. Another idea is to construct high strong foundation walls under the wooden housing to avoid flooding. The piloti structure whose first floor is supported by columns with no walls is effective to decrease flood water pressure to the building. The base isolated building on the piloti structure can decrease both flood load and earthquake load.

Keywords: flood, building structure, countermeasure, piloti, base isolation

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State and Challenges of Disaster Waste Management - Lessons from Recent Disasters –

*Yuichi Moriguchi[1], Masahiro Osako[2]

1. Graduate School of Engineering, The University of Tokyo, 2. Center for Material Cycles and Wasre Management Research, National Institute for Environmental Studies

Though legislative, institutional, technical and practical responses to disaster waste management have been strengthened since the Great East Japan Earthquake, recent disasters have been revealing further lessons to be learned. This presentation will show the current state and challenges of disaster waste management.

Keywords: Disaster waste, Tentative storage site, Separation and treatment, D.Waste-Net

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Evacuation Planning for School Children and Community Residents

*Takeshi Sato[1], Yoshiaki Yazaki[2]

1. Tohoku University, 2. Institute of Safety Education for School Children

The time line and the evacuation plan will help to reduce the number of effectively cut down human damage from floods or typhoons. On making the plan, It's difficult to consider the local characteristics of nature for school teachers and community residents because of a lack of special knowledge. Academic contribution is expected to support them. A few implementation cases by authors are introduced.

Keywords: Natural Disaster, Evacuation, Education

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Health Emergency and Nursing on Flood Disaster

*Sakiko Kanbara[1], Aiko Yamamoto[2]

1. University of Kochi, 2. Shitennoji University

It can be reduced in risk by comprehensive environmental improvement and holistic human care, and it is urgent to discuss as interdisciplinary and generalizable issues.

Keywords: Flood, Health Emergency, Nursing

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General discussion

*Jun Matsumoto[1,2], Yukihiro Takahashi[3], Akira Wada[4]

1. Tokyo Metropolitan University, 2. JAMSTEC, 3. Hokkaido University, 4. Tokyo Institute of Technology

In this session, general discussion will be conducted.

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | Convention Hall B 2F

[O-07] Kitchen Earth Science: Let's stimulate your brain by hands-on experiments!

convener:Ichiro Kumagai(School of Science and Engineering, Meisei University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kei Kurita, Mie Ichihara(Earthquake Research Institute, University of Tokyo), Chairperson:Ichiro Kumagai(Meisei University), Miwa Kuri(東北大学災害科学国際研究所), Mie Ichihara(Earthquake Research Institute, The University of Tokyo), Kei Kurita

"Kitchen Earth Science" aims at understanding a natural phenomenon in Earth and planetary sciences by analogue experiments using goods and tools in our daily life. Analogue experiments have a function to unveil the fundamental physics governing the phenomenon. At the same time, they essentially include uncertainties so that unexpected results are frequently obtained, which have a potential for surprising discoveries. These findings also provide a good opportunity for deeply thinking, and raise new questions to explore. Such experience is precious not only for young researchers in Earth and planetary sciences, but also non-expert people who need a scientific thinking to live wisely. In this session, we focus on "advantages of doing hands-on science experiments" and discuss the significance of analogue experiments with uncertainties, which cause unpredictable results: even if the experiment fails, we learn a lot of things from the failure which may lead to a great success. We are accepting a variety of experimental researches and case studies on scientific education such as introductory educational experiments for Earth and planetary sciences in elementally and junior/high schools, general science education and interdisciplinary researches in post-high schools, and new approaches to citizen science and outreach. We welcome all the participants who are interested in Kitchen Earth Science to stimulate your brain by hands-on science experiments.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[O07-01] Analogue experiments for understanding a crystal morphology variation of igneous rocks using a no-calorie sweetener

*Kuniyuki Furukawa[1], Ririka Watanabe[1], Risa Ito[1], Saori Kotani[1] (1.Faculty of Business Administration, Aichi University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[O07-02] Making volcanic edifice with edible lava

*Tatsuo Kanamaru[1], Akihiko Fujinawa[2] (1.Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University, 2.Department of Earth Sciences, Faculty of Science, Ibaraki University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[O07-03] Columnar joint: Geometric pattern analysis and analogue experiment using starch pastes

*Yuri Akiba[1], Aika Takashima[1], Hiroyuki Shima[2] (1.Graduate School of Life and Environmental Sciences, University of Yamanashi, 2.Department of Environmental Sciences, University of Yamanashi)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[O07-04] Viscoelastic characterization of a solid projectile impact onto a dense potato starch suspension

Kazuya Egawa[2], *Hiroaki Katsuragi[1] (1.Graduate School of Environmental Studies, Nagoya University, 2.Department of Earth and Planetary Sciences, Nagoya University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[O07-05] Pattern formation within a sandpile formed by a mixture of grains: The selection of stratification and segregation patterns

★Invited Papers

*Michiko Shimokawa[1], Hidestugu Sakaguchi[2] (1.Fukuoka Institute of Technology, 2.Kyushu University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[O07-06] Measuring radiation by DIY Geiger Counter Kit GC10

*George HASHIMOTO[1], Yusuke KOSHIO[1] (1.Department of Earth Sciences, Okayama University)

Analogue experiments for understanding a crystal morphology variation of igneous rocks using a no-calorie sweetener

*Kuniyuki Furukawa[1], Ririka Watanabe[1], Risa Ito[1], Saori Kotani[1]

1. Faculty of Business Administration, Aichi University

Crystallization of a magma is progressed during cooling. The number and morphology of crystals are chiefly controlled by degree of undercooling of a magma. Since igneous rocks are generally formed under various cooling profiles, crystal occurrences of natural igneous rocks are varied. As it is generally known, difference of crystal textures between plutonic and volcanic rocks are generated from difference of cooling rate. However, only that knowledge is not enough to understand results of field or microscopic observations. Therefore, students, who major in geology or petrology, should be understand general crystallization process. In this presentation, we propose the easy analog experiments to understand crystallization process of silicate melt.

Erythritol ($C_4H_{10}O_4$), which is no-calorie sweetener, is used for the experiments. The melting temperature is 121 ˚C, and erythritol can be easily melted using a hot plate. Since the melted erythritol is relatively low viscosity, crystallization is easily induced even if low degree of undercooling. This characteristic is different from a sugar.

We melted 25 g of erythritol in a petri dish with 90 mm in diameter. The petri dish including melted erythritol was cooled via various cooling rate. In the result, the crystal morphology was varied from euhedral to dendritic, and spherulitic with increasing degree of undercooling. The crystal size tends to be small with increasing degree of undercooling. The occurrences of crystal textures are consistent with those of natural igneous rocks.

The cooling rate can be easily quantified using an infrared thermometer. The boundary of cooling rate between euhedral and dendritic crystal formations was about 12 ˚C/min. The boundary of cooling rate between dendritic and spherulitic crystal formations was about 40 ˚C/min. Furthermore, latent heat could be also analyzed when crystallization progress. Latent heat is important, because it affect to rheology of advancing lavas or a magma chamber. The in-situ crystallization can be observed under a microscope. We consider that these experiments are strongly effective for geology and petrology education.

Keywords: Erythritol, Crystallization, Igneous rock

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Making volcanic edifice with edible lava

*Tatsuo Kanamaru[1], Akihiko Fujinawa[2]

1. Department of Earth and Environmental Sciences, College of Humanities & Sciences, Nihon University, 2. Department of Earth Sciences, Faculty of Science, Ibaraki University

Volcano is a window through which inside of the living earth can be seen, and also gives us a lot of grace and pleasure. On the other hand, volcanic disasters always hit human societies sitting on volcanic countries. In order to feel familiar with the volcano and get along well with the volcanoes, it is very important to know how the volcanoes have been formed. For this purpose, it is best to observe directly a volcanic eruption or perform a geological survey. However, it is difficult for non-experts to do the field survey. Therefore, efforts to make volcanoes understandable easily even by non-experts have to be made. In fact, the effort such as flow experiment of lava flow using miniature model, analog experiment of eruption using food, etc. have been conducted actively in recent years (e.g. Hayashi, 2006). In this presentation, we will introduce a lava flow experiment using pseudo-magma material prepared by mixing chocolate, gelatin, milk and heating it in a microwave oven. In addition, making pseudo-scoria formed by foaming of the same substance will be exhibited. In the lava flow experiment, it is possible to produce characteristic forms on the real lava flow surface, such as lava inflation, lava levee, ropy lava, etc. Pseudo-scoria produced by the experiment is optimum for observation of bubbling of lava.

Keywords: chocolate lava, gelatin, edible volcano

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Columnar joint: Geometric pattern analysis and analogue experiment using starch pastes

*Yuri Akiba[1], Aika Takashima[1], Hiroyuki Shima[2]

1. Graduate School of Life and Environmental Sciences, University of Yamanashi, 2. Department of Environmental Sciences, University of Yamanashi

Columnar joints are prismatic cracks that regularly penetrate the rock body. They are formed by contraction of cooled lava followed by sequential crack advances. Worldwide famous examples include: Giant's Causeway in Northern Ireland, Fingal Cave in the UK, and Devil's Tower in the United States.

Despite of much efforts reported thus far, a clear understanding for its formation mechanism has not yet been obtained, mainly because of the difficulty of experimental reproduction. In the last two decades, the situation changed drastically; it was discovered that regular crack structures, which look similar to columnar joints, can be realized very easily using starch paste. The way to make them is shown below. First, starch powder and distill water is mixed thoroughly to make paste. Next, this paste is poured into a container. Then, the surface of the paste is irradiated by an incandescent lamp, and it is left for a long time. As the moisture evaporates from the surface, the paste goes drying and causes cracking. As time elapses further, the cracks at the surface progress inward, and we finally obtain a prismatic structure which regularly penetrates the entire paste. After completely drying, a polygonal network pattern is generated on the surface of the paste.

Obviously, columnar joint and starch paste are different in the chemical composition, length scale, and crack initiation factors. But a similar prismatic crack is formed --- Why? This question motivated us to investigate the statistical properties of the polygonal pattern in both two systems.

Our drone aerial shooting of columnar joints was carried out at the following four domestic sites: (1) Tatami-ishi in Okinawa, (2) Tatami-ga-fuchi in Yamaguchi, (3) Tawara-iso in Shizuoka, and (4) Hi-no-misaki in Shimane. Importantly, the SiO_2content in constituent igneous rocks depends on the sites: the sites 1 and 3 are andesitic, the site 2 is basaltic, and the site 4 is rhyolitic. This difference would have influenced the statistical properties of the polygonal network pattern observed at present. Meanwhile, our starch-paste experiment was aimed at evaluation of the following two effects on the geometry of the polygonal crack pattern: (1) the fluctuation width in the size distribution of constituent starch particles, and (2) the degree of sphericity of the particles. To this end, we used two types of starch, corn starch and potato starch. We also examined the degree of correlation between the film thickness of the paste and the crack pattern obtained.

The first main finding was regarding the characteristic length scale of the polygonal network. For columnar joints, the length scale varies from sites to sites, probably because of the difference in the SiO_2 content. For the desiccated starch paste, the length scale increased with the film thickness only for the potato starch paste. The latter result can be explained from the water diffusion process in the paste and the spatial nonuniformity in the water concentration. Since both the water diffusion and concentration in the paste are directly affected by the size and shape of the constituent particles, our result indicates that the geometry of the dry crack pattern strongly depends on the particles' size and shape.

The second main finding was regarding the number of vertices in polygons. In columnar joint, pentagons

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and hexagons occurred in an almost equal frequency. On the other hand, in desiccated starch paste, only pentagons frequently occurred. This result can be interpreted by the difference in cooling/drying speed.

The third finding was regarding the probability distribution of polygon area. Both for the two systems, the distributions are well fitted on the curve of gamma distribution. This suggests the existence of a unified pattern formation mechanism which is common to both the cooling contraction of magma and the drying shrinkage of paste. Details of the results and its interpretation will be given in my talk of the session.

Keywords: igneous rock, rock fracture, drying paste, desiccation crack, polygonal pattern

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Viscoelastic characterization of a solid projectile impact onto a dense potato starch suspension

Kazuya Egawa[2], *Hiroaki Katsuragi[1]

1. Graduate School of Environmental Studies, Nagoya University, 2. Department of Earth and Planetary Sciences, Nagoya University

Dense suspension of non-Browning particles (e.g. mixture of water and potato starch) shows complex rheological properties such as discontinuous shear thickening (DST) [1]. Usually, DST is defined by the sudden jump of viscosity at a certain shear strain rate. The viscosity jump is observed in steady-state rheometry. However, in a very recent study, elasticity of DST fluid has also been measured by a steady penetration of a rod into a DST fluid [2]. In addition to the steady penetration, various impact experiments onto DST suspensions have also been performed to reveal the fundamental physical process of DST. The solid-like and/or peculiar behaviors have been found in the impacted DST fluid as well (e.g. dynamic jamming [3], dynamic fracturing [4], and negative pressure pulse [5]). Moreover, peculiar surface deformation and/or stable hole structure of the vibrated DST fluid has also been found under the influence of vibration [6]. Nevertheless, the origin of DST has not yet been understood well. Much more detail analyses of the transient rheological properties of DST fluid is necessary. The impact response is a useful way to approach the transient dynamics, Therefore, in this study, we perform a simple solid-projectile impact onto a DST fluid target (dense potato starch suspension), in order to observe the penetration and rebound dynamics. From the experimental results, the rebound timescale and restitution coefficient are measured. To characterize the transient viscoelasticity, we assume a simple linear viscoelastic model. Using the model, the effects of impact inertia, boundary conditions, and mechanical vibration on the rheological properties of the impacted DST fluid are systematically studied. Besides, to investigate the effect of vibration to the rheological properties of DST fluid, mechanical vibration is also used. Namely, the transient viscoelasticity of the vibrated DST fluid is experimentally measured. These results will be presented.

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[5] S. Nagahiro & H. Nakanishi, Phys. Rev. E 94 062614(2016)
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Keywords: impact, discontinuous shear thickening

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Pattern formation within a sandpile formed by a mixture of grains: The selection of stratification and segregation patterns

*Michiko Shimokawa[1], Hidestugu Sakaguchi[2]

1. Fukuoka Institute of Technology, 2. Kyushu University

By pouring a mixture of two types of grains into a large vertical cell of narrow dimensions, an avalanche occurs toward the bottom of the sandpile, and the mixed grains separate into their respective grain types due to the Brazil nut effect, which is caused by the vibration of the avalanche. The effect causes spontaneous formations of stratification patterns or segregation patterns in a sandpile. The selection of the pattern in the sand pile is determined by a competition of angles of repose and the grain sizes of the two grain types. In the condition of a formation of a segregation pattern, a size of grain A is larger than that of grain B, and a repose angle of grain A is smaller than that of grain B. On the other hand, the grain size and repose angle of grain A are larger than those of grain B for the formation of the stratification pattern. We investigate pattern formation in a sandpile by pouring a ternary mixture of grains into a narrow vertical cell. Size segregation in avalanches causes the formation of patterns. Four kinds of patterns emerge: stratification, segregation, upper stratification–lower segregation, and upper segregation–lower stratification. A phase diagram is constructed in a parameter space of θ_{11}/θ_{33} and θ_{22}/θ_{33}, where θ_{11}, θ_{22}, and θ_{33} are the repose angles of small, intermediate, and large grains, respectively. To qualitatively understand pattern formation, a phenomenological model based on a roll-or-stay rule is proposed. A similar pattern formation is found in a numerical simulation of the phenomenological model. These results suggest that the ratios of the repose angles of the three grain types are important for pattern formation within a sandpile.

Keywords: pattern formation, sand pile, avalanche

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Measuring radiation by DIY Geiger Counter Kit GC10

*George HASHIMOTO[1], Yusuke KOSHIO[1]

1. Department of Earth Sciences, Okayama University

Radiation level is measured by DIY Geiger counger kit GC10.

Keywords: electronic kit, radiation level

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[J] Poster | O (Public)：Public

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_1

[O-07] Kitchen Earth Science: Let's stimulate your brain by hands-on experiments!

convener:Ichiro Kumagai(School of Science and Engineering, Meisei University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kei Kurita, Mie Ichihara(Earthquake Research Institute, University of Tokyo)

"Kitchen Earth Science" aims at understanding a natural phenomenon in Earth and planetary sciences by analogue experiments using goods and tools in our daily life. Analogue experiments have a function to unveil the fundamental physics governing the phenomenon. At the same time, they essentially include uncertainties so that unexpected results are frequently obtained, which have a potential for surprising discoveries. These findings also provide a good opportunity for deeply thinking, and raise new questions to explore. Such experience is precious not only for young researchers in Earth and planetary sciences, but also non-expert people who need a scientific thinking to live wisely. In this session, we focus on "advantages of doing hands-on science experiments" and discuss the significance of analogue experiments with uncertainties, which cause unpredictable results: even if the experiment fails, we learn a lot of things from the failure which may lead to a great success. We are accepting a variety of experimental researches and case studies on scientific education such as introductory educational experiments for Earth and planetary sciences in elementally and junior/high schools, general science education and interdisciplinary researches in post-high schools, and new approaches to citizen science and outreach. We welcome all the participants who are interested in Kitchen Earth Science to stimulate your brain by hands-on science experiments.

[O07-P01] Application of kitchen earth science for multidisciplinary and interdisciplinary education

*Miwa Kuri[1] (1.International Research Institute of Disaster Science, Tohoku University)

[O07-P02] Considering controlling factors of eruption styles through syrup eruption experiments

*Mie Ichihara[1], Kazuya Yamakawa[1], Kurumi Iwahashi[1], Akira Nishijo[1], Yo Kanno[1] (1.Earthquake Research Institute, University of Tokyo)

[O07-P03] Cooking karinto, analogical link to magmatic vesiculation and explosion

*Kei Kurita[1], Ichiro Kumagai[3], Mie Ichihara[1], Ayumi Ogawa[2], Michiyo Kumagai[2], yusaku nagata[2], Midori Kasai[2] (1.The University of Tokyo, 2.Ochanomizu University, 3.Meisei University)

Application of kitchen earth science for multidisciplinary and interdisciplinary education

*Miwa Kuri[1]

1. International Research Institute of Disaster Science, Tohoku University

Scince research and education on problem-solving type are required, universities are introducing educational programs aimed at fusion of disciplines and interdisciplinary research and training for human resources. Participatory project-based methods are actively being introduced.
"Kitchen Earth Science" session in the past JpGU, had some developments of teaching materials aimed at raising awareness of specific phenomena and helping understanding, but in this thesis, we will discuss how to apply to team project type education We categorized these cases.
Despite the fact that the time limit is great due to the educational program outside the main major, the importance is put on the practice in the area, and as a result, the expectation from the area is large.
Kitchen Earth Sciences : Simple analog experiments helped understand disaster mechanisms, history shows the frequency and magnitude of disasters. It is possible to deal with specific phenomena such as liquefaction phenomena and river overflowing in multiple ways or to deal with multiple phenomena that can occur in the same area, from multiple fields such as history, mechanism, measures, It was excellent in that it was able to comprehend the characteristics of the way of thinking among fields in the course of making a series of educational curriculums examined.
Living science: Teaching material development using card games and communication terminals was conducted. It is excellent for flexible applications according to age and interest, is excellent in portability, has many opportunities to practice in the region, is excellent as a trigger to listen to the voice of the region, verification of educational effect It was also excellent in terms of easy to do. However, the elements of analog experimental thinking that Kitchen Earth Science had originally been proud of were poor.
Garage Earth Sciences: Material cost is more expensive than kitchen earth science, but while utilizing commercial products, customize according to purpose, learn to divide roles according to specialty in team and create efficient division of labor It was excellent as opportunity.

Keywords: kitchen earth science, multidisciplinary education, interdisciplinary education

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Considering controlling factors of eruption styles through syrup eruption experiments

*Mie Ichihara[1], Kazuya Yamakawa[1], Kurumi Iwahashi[1], Akira Nishijo[1], Yo Kanno[1]

1. Earthquake Research Institute, University of Tokyo

An eruption experiment by mixing vinegar and baking soda is a simple but indicative analog experiment to study volcanic eruptions. Based on the original work by Takcuchi (2006), we have developed an apparatus that allows us also to simulate geophysical observations like ground inflation and eruption infrasound. Also, to reproduce a typical eruption scenario that is “an eruption is triggered by mixing of two magmas," we have employed a method that is to make an eruption by mixing two syrup solutions one with acid and another with sodium hydrogen carbonate. This experiment has been used in outreach activity and also provided new insights that are useful in volcanology (Kanno and Ichihara, 2018). This paper reports our improvement by which we can reproduce a variety of eruption styles in a more realistic way.

The model volcano consists of a PET bottle and a transparent plastic tube. The tube is fixed to the bottle cap by an original connector. The tube end is initially closed by a rubber plug. When sufficient pressure builds up in the bottle by foaming, it spontaneously opens and an eruption starts.

In the previous method, we poured the syrups into the bottle one after another and closed the cap. We left a sufficient empty volume to prevent overflowing. Then, the tube needed to extend to the bottom of the bottle to lead a syrup eruption instead of a short gas burst. These points have been pointed out to be unrealistic.

We have developed a new connector, which allows to input a second syrup into an arbitral position of the reservoir containing the first syrup and output the mixture upward into the conduit. Then, we can reproduce various eruption styles in better controlled and more realistic ways. We are going to use this apparatus in an experimental volcanology seminar for the graduate students in volcanology. We report the results and effects of the seminar as well.

Keywords: Volcano, Analog experiment, Eruption dynamics

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Cooking karinto, analogical link to magmatic vesiculation and explosion

*Kei Kurita[1], Ichiro Kumagai[3], Mie Ichihara[1], Ayumi Ogawa[2], Michiyo Kumagai[2], yusaku nagata[2], Midori Kasai[2]

1. The University of Tokyo, 2. Ochanomizu University, 3. Meisei University

Karinto is one of the typical traditional sweets, which is classified as a puffed confectionery. When we examine the cross section of karinto we can recognize amazing resemblance to the texture of vesiculated pyroclastic materials. This gives us an idea that the formation mechanism of karinto seems collateral to that of pumice and scoria in volcanic process and it would help deep understanding of magmatic vesiculation process. This is the starting point of our research on karinto.
Here we report experimental investigation on the formation of karinto,cooking process. Particularly we focus on the sound generation during the cooking to characterize vesiculation process. The basic material of the starting dough is flour,baking soda,sugar and water. Baking soda and water determine volatility of the sample. Heating induces vaporization of water and thermal decomposition of baking soda, which result in volume-expansion and create a peculiar vesiculated texture. To see the control of this we tested following 4 sets of the composition;
Sample A:flour 50g,baking soda 2g,sugar 10g,water 25g
Sample B:flour 50g,baking soda 0g,sugar 0g,water 25g
Sample C:flour 50g,baking soda 2g,sugar 0g,water 25g
Sample E:flour 50g,baking soda 0g,sugar 0g,water 30g
Sample A is based on the standard recipe of karinto. Sample C and E seem interesting to see the effect of volatile components.

In the cooking experiment we put the dough of 50mm in length x 10mm in width x 6mm in thickness into hot oil at 180-170C. Soon after start of deep frying familiar cooking sound becomes audible. We recorded this and took movie by high speed camera to inspect size and location of bubbles which emanate from the dough. Common to all the composition the sound changes systematically; in the first several minutes continuous sound with flat spectrum to 25KHz emanates while after this high frequency component gradually decreases and prominent peaks in the spectrum appear in several hundreds Hz, which sound as "chant d'Oiseau". Associated with this transition size of bubbles which appear on the surface of dough changes from broad distribution to homogeneous. Also the vesiculation points become localized. All these observations are consistently interpreted that after 4-5minutes steady paths of the gas emission from the inside have been set up. The talented experienced patissier could discriminate the difference of the sound to inspect maturity.
Only in the case of Sample E destructive explosions were observed at about 2 minutes from the start. During heating two competing processes are working inside the dough:solidification which proceeds from the outside and gas formation. Both are driven by higher temperature. When the solidification advances ahead hard shell is formed to impede escape of gas, which results in accumulation of high vapour pressure inside. This is the cause of the explosion. The standard recipe smartly avoids this route by arranging combination of the ingredients but in our experiments we seek the condition for explosion.
In the presentation we report progressive evolution of the spectrum of cooking sound with textural evolution in relation with magmatic process.

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Keywords: magmatic vesiculation, puffed confectionery, explosion

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[J] Poster | O (Public)：Public

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_2

[O-07] Kitchen Earth Science: Let's stimulate your brain by hands-on experiments!

convener:Ichiro Kumagai(School of Science and Engineering, Meisei University), Miwa Kuri(International Research Institute of Disaster Science, Tohoku University), Kei Kurita, Mie Ichihara(Earthquake Research Institute, University of Tokyo)

"Kitchen Earth Science" aims at understanding a natural phenomenon in Earth and planetary sciences by analogue experiments using goods and tools in our daily life. Analogue experiments have a function to unveil the fundamental physics governing the phenomenon. At the same time, they essentially include uncertainties so that unexpected results are frequently obtained, which have a potential for surprising discoveries. These findings also provide a good opportunity for deeply thinking, and raise new questions to explore. Such experience is precious not only for young researchers in Earth and planetary sciences, but also non-expert people who need a scientific thinking to live wisely. In this session, we focus on "advantages of doing hands-on science experiments" and discuss the significance of analogue experiments with uncertainties, which cause unpredictable results: even if the experiment fails, we learn a lot of things from the failure which may lead to a great success. We are accepting a variety of experimental researches and case studies on scientific education such as introductory educational experiments for Earth and planetary sciences in elementally and junior/high schools, general science education and interdisciplinary researches in post-high schools, and new approaches to citizen science and outreach. We welcome all the participants who are interested in Kitchen Earth Science to stimulate your brain by hands-on science experiments.

[O07-P01] Application of kitchen earth science for multidisciplinary and interdisciplinary education

*Miwa Kuri[1] (1.International Research Institute of Disaster Science, Tohoku University)

[O07-P02] Considering controlling factors of eruption styles through syrup eruption experiments

*Mie Ichihara[1], Kazuya Yamakawa[1], Kurumi Iwahashi[1], Akira Nishijo[1], Yo Kanno[1] (1.Earthquake Research Institute, University of Tokyo)

[O07-P03] Cooking karinto, analogical link to magmatic vesiculation and explosion

*Kei Kurita[1], Ichiro Kumagai[3], Mie Ichihara[1], Ayumi Ogawa[2], Michiyo Kumagai[2], yusaku nagata[2], Midori Kasai[2] (1.The University of Tokyo, 2.Ochanomizu University, 3.Meisei University)

Application of kitchen earth science for multidisciplinary and interdisciplinary education

*Miwa Kuri[1]

1. International Research Institute of Disaster Science, Tohoku University

Scince research and education on problem-solving type are required, universities are introducing educational programs aimed at fusion of disciplines and interdisciplinary research and training for human resources. Participatory project-based methods are actively being introduced.
"Kitchen Earth Science" session in the past JpGU, had some developments of teaching materials aimed at raising awareness of specific phenomena and helping understanding, but in this thesis, we will discuss how to apply to team project type education We categorized these cases.
Despite the fact that the time limit is great due to the educational program outside the main major, the importance is put on the practice in the area, and as a result, the expectation from the area is large.
Kitchen Earth Sciences : Simple analog experiments helped understand disaster mechanisms, history shows the frequency and magnitude of disasters. It is possible to deal with specific phenomena such as liquefaction phenomena and river overflowing in multiple ways or to deal with multiple phenomena that can occur in the same area, from multiple fields such as history, mechanism, measures, It was excellent in that it was able to comprehend the characteristics of the way of thinking among fields in the course of making a series of educational curriculums examined.
Living science: Teaching material development using card games and communication terminals was conducted. It is excellent for flexible applications according to age and interest, is excellent in portability, has many opportunities to practice in the region, is excellent as a trigger to listen to the voice of the region, verification of educational effect It was also excellent in terms of easy to do. However, the elements of analog experimental thinking that Kitchen Earth Science had originally been proud of were poor.
Garage Earth Sciences: Material cost is more expensive than kitchen earth science, but while utilizing commercial products, customize according to purpose, learn to divide roles according to specialty in team and create efficient division of labor It was excellent as opportunity.

Keywords: kitchen earth science, multidisciplinary education, interdisciplinary education

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Considering controlling factors of eruption styles through syrup eruption experiments

*Mie Ichihara[1], Kazuya Yamakawa[1], Kurumi Iwahashi[1], Akira Nishijo[1], Yo Kanno[1]

1. Earthquake Research Institute, University of Tokyo

An eruption experiment by mixing vinegar and baking soda is a simple but indicative analog experiment to study volcanic eruptions. Based on the original work by Takcuchi (2006), we have developed an apparatus that allows us also to simulate geophysical observations like ground inflation and eruption infrasound. Also, to reproduce a typical eruption scenario that is “an eruption is triggered by mixing of two magmas," we have employed a method that is to make an eruption by mixing two syrup solutions one with acid and another with sodium hydrogen carbonate. This experiment has been used in outreach activity and also provided new insights that are useful in volcanology (Kanno and Ichihara, 2018). This paper reports our improvement by which we can reproduce a variety of eruption styles in a more realistic way.

The model volcano consists of a PET bottle and a transparent plastic tube. The tube is fixed to the bottle cap by an original connector. The tube end is initially closed by a rubber plug. When sufficient pressure builds up in the bottle by foaming, it spontaneously opens and an eruption starts.

In the previous method, we poured the syrups into the bottle one after another and closed the cap. We left a sufficient empty volume to prevent overflowing. Then, the tube needed to extend to the bottom of the bottle to lead a syrup eruption instead of a short gas burst. These points have been pointed out to be unrealistic.

We have developed a new connector, which allows to input a second syrup into an arbitral position of the reservoir containing the first syrup and output the mixture upward into the conduit. Then, we can reproduce various eruption styles in better controlled and more realistic ways. We are going to use this apparatus in an experimental volcanology seminar for the graduate students in volcanology. We report the results and effects of the seminar as well.

Keywords: Volcano, Analog experiment, Eruption dynamics

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Convention Hall B 2F

[O-08] How to make the image of the earth's phenomenon to the general people in the Geopark

convener:Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Yayoi ICHIHASHI(Sado Island Geopark Promotion Office), Hokuto Obara(Mine-Akiyoshidai Karst Plateau Geopark Promotion Council), Marekazu OHNO(Unzen Volcanic Area Geopark Promotion Office), Chairperson:Yayoi Ichihashi, Hokuto Obara, Hiroko Imai, Suzuka Koriyama(San'in Kaigan Geopark Promotion Council), Noritaka Matsubara(兵庫県立大学大学院)

unesco global geoparks give international recognition for sites that promote the importance and significance of protecting the Earth's geodiversity through actively engaging with the local communities. in order for the general people to understand the earth's activity, it is necessary to imagine the phenomenon of the earth. in this session, we discuss about how to make the image of the earth's phenomenon to the general people in the Geopark.

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[O08-01] Significance of the guide to introduce the landscape interestingly

★Invited Papers

*Daisuke Fukushima[1] (1.Sakurajima Museum)

11:15 AM - 11:45 AM JST | 2:15 AM - 2:45 AM UTC

[O08-02] Understanding of "geology" without difficult explanation. - Let's conduct experiment to tell about geology more easily. -

★Invited Papers

*Hikaru Yokoyama[1] (1.Hokusho University)

11:45 AM - 12:15 PM JST | 2:45 AM - 3:15 AM UTC

[O08-03] The appealing points and challenges of Japanese geoparks, as seen from a foreigner’s point of view.

★Invited Papers

*Jagoda Woloszyn[1] (1.Oki Islands UNESCO Global Geopark Promotion Committee)

Significance of the guide to introduce the landscape interestingly

*Daisuke Fukushima[1]

1. Sakurajima Museum

One of the objectives of the geopark is to convey the connection between the earth, people and nature. Many of those who have learned earth science can imagine the formation of the earth from the topography and geology, from which you can imagine the connection with people and nature. However, since many general people do not have knowledge of earth science, it is difficult to understand the story of the connection between the earth, people and nature from the landscape in front of the eyes.

On the other hand, there are many people who have deep knowledge about their hobbies and work, can imagine and enjoy various things. For example, if a person who likes history went to a famous battlefield, it would be possible to imagine and enjoy events of hundreds of years ago. However, it is familiar scenery for many general people. Whether you can enjoy the scenery is proportional to knowledge and imagination. If you have a lot of knowledge, the range you can imagine will expand and you will be able to enjoy various sceneries.

The role of the guides is to introduce the scenery interestingly even if the customer does not have knowledge. The guides provide the necessary knowledge to bring out imagination, take you to a place suitable for imagining, use imagery, photographs, illustrations etc so that guides and customers can imagine similar images. Then, the scenery in front of you seems to change, and you can know the story. It is the best way to tell the connection between earth and people and nature. Therefore, the role of the guide in geoparks is very important.

Keywords: geopark, guide, dissemination

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Understanding of "geology" without difficult explanation. - Let's conduct experiment to tell about geology more easily. -

*Hikaru Yokoyama[1]

1. Hokusho University

In the geopark, it is necessary to positively transmit the geoscientific appeal of the area. However, in Japan, many people are not sufficiently educated about geology. Therefore, it is very important task to communicate about the geological phenomena to the citizen easily.

Model experiments are one effective means to tell phenomena difficult to express in words easily. Several activities have been conducted to deepen understanding of geology through model experiments. "The kitchen volcano experiments" is an example of a typical model experiment. Experiments that can easily model geological phenomena and convey it are essential communication tools for the dissemination of geoparks and educational activities.

In this presentation, I will give some examples of experiments to model and convey complex geological phenomena. I will propose the effect of dissemination activities through experiments and how to utilize the experiment in geopark.

Keywords: Science communication, Outreach, Education

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The appealing points and challenges of Japanese geoparks, as seen from a foreigner’ s point of view.

*Jagoda Woloszyn[1]

1. Oki Islands UNESCO Global Geopark Promotion Committee

It has been almost three years since I started my work as a Coordinator of International Relations at the Oki Islands UNESCO Global Geopark Promotion Committee. Before coming here, I did not even know that organizations like geoparks existed. Therefore, at the beginning, Japanese geoparks became my model for geoparks. During my presentation I will talk about the appealing points of geoparks in Japan from an amateur’ s point of view.

Geopark Promotion Committees in Japan have the necessary resources to gather information about not only the local geology, but also the local nature, history and culture. Therefore, they can function as a hub for human resource development projects and high-quality tourism product creation.
I wish to look at the challenges that geopark promotion committees face in Japan, as well as talk about the differences between Japanese and European geoparks. Focusing on the differences resulting from the different starting points of the networks, differences in geopark office organization style and culture differences in working style, I will touch upon what I believe the networks can learn from each other.

Keywords: geopark, networks, differences in management style

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[J] Oral | O (Public)：Public

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | Convention Hall B 2F

[O-08] How to make the image of the earth's phenomenon to the general people in the Geopark

convener:Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Yayoi ICHIHASHI(Sado Island Geopark Promotion Office), Hokuto Obara(Mine-Akiyoshidai Karst Plateau Geopark Promotion Council), Marekazu OHNO(Unzen Volcanic Area Geopark Promotion Office), Chairperson:Yayoi Ichihashi, Hokuto Obara, Hiroko Imai, Noritaka Matsubara(兵庫県立大学大学院), Suzuka Koriyama(San'in Kaigan Geopark Promotion Council)

unesco global geoparks give international recognition for sites that promote the importance and significance of protecting the Earth's geodiversity through actively engaging with the local communities. in order for the general people to understand the earth's activity, it is necessary to imagine the phenomenon of the earth. in this session, we discuss about how to make the image of the earth's phenomenon to the general people in the Geopark.

1:45 PM - 2:15 PM JST | 4:45 AM - 5:15 AM UTC

[O08-04] What do we need to do fun geotours that interests the earth?

★Invited Papers

*kana nishitani[1] (1.Global nature club)

2:15 PM - 2:45 PM JST | 5:15 AM - 5:45 AM UTC

[O08-05] The Important Things in Communicating Earth's Activity to Local Residents: the Awareness during Four Years after Changing a Job from a Geoscience Postdoc to a Curator

★Invited Papers

*Kyoko Kanayama[1] (1.San'in Kaigan Geopark Museum of the Earth and Sea, Tottori Prefectural Government)

2:45 PM - 3:15 PM JST | 5:45 AM - 6:15 AM UTC

[O08-06] "Blatamori" How to communicate the earth activities valued by guide guides

★Invited Papers

*Makoto Hasuoka[1], Yusuke Suzuki[2], Hiroko Imai[3] (1.Bandai-san Geopark Council, 2.Izu Peninsula Geopark Promotion Council, 3.COM SUPPORT OFFICE)

What do we need to do fun geotours that interests the earth?

*kana nishitani[1]

1. Global nature club

I think that guides need to improve interpretation skills in order to make customers fun and make feel be on the earth.

I will apply my daily guide to the four elements "①Theme ②Organized ③Relative ④Enjoyable" which are said to be necessary for the interpretation, will organize it. And I will consider what is important for geo guide.

Keywords: Geopark, guide

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The Important Things in Communicating Earth's Activity to Local Residents: the Awareness during Four Years after Changing a Job from a Geoscience Postdoc to a Curator

*Kyoko Kanayama[1]

1. San'in Kaigan Geopark Museum of the Earth and Sea, Tottori Prefectural Government

Four years ago, I changed a job from a postdoctoral researcher at a university to a curator at the Tottori Prefectural Government. After my career change, a target for my communication changed from scientists and graduate students having a passion for earth sciences to local people and administrative staff who had never learned earth sciences deeply. How can I let them know the interest for earth sciences?
I believe the interest about earth sciences is to come to realize or imagine that "the earth is active". However, I feel many people are less interested in earth sciences because there is little opportunity to feel its interest. One of my missions as a curator is simply passing on "the earth is active" to as many people as possible.
What I gradually learned from my experience as a curator for four years is that telling memories of landscape and life which listeners had seen could link to their interest for earth sciences when I tell about earth activity. Including these stories, I would like to talk about some perceptions that I gained through the curatorial work in my presentation.

Keywords: Earth sciences, geopark, interpretation

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"Blatamori" How to communicate the earth activities valued by guide guides

*Makoto Hasuoka[1], Yusuke Suzuki[2], Hiroko Imai[3]

1. Bandai-san Geopark Council, 2. Izu Peninsula Geopark Promotion Council, 3. COM SUPPORT OFFICE

It is not easy for ordinary people and local residents who do not have expertise to image the earth's activities in the geopark - know the importance of geodiversity. In each geopark, local people such as experts and geo guides unravel the phenomena related to the activities of the earth and the relationship between people and the earth, communicate their enjoyment and importance to the general public through guided tours and activities There.
NHK Blatamori introduces to the tea room that it is close to activities that this geopark region is practicing.This program is a program of the concept that Mr. Tamori of the guru walking master approaches the history of the unknown city and the lives of people while walking around the glove.

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[O08-P01] An analysis of the implementation of Mikasa Geopark`s experienced-based GeoTour and its impacts on recruitment and changes in the participant population.

*kei SHIMOMURA[1,2], souta KAMIGUCHI[1,2] (1.Mikasa Geopark Promotion council, 2.Regional Development and Geopark Promotion Division, Mikasa City Office)

[O08-P02] Strategy for revaluation and promotion of Toya-Usu UNESCO Global Geopark through SDGs

*Nire Kagaya[1] (1.Toya-Usu UNESCO Global Geopark Council)

[O08-P03] Examination of the way to convey geo diversity of Mt. Apoi Geopark - Through efforts of geo tour outside the geopark area -

*KATO SATOMI[1] (1.samani town office)

[O08-P04] Geosite Cleanup Activities Leading to Solutions for Global Environmental Problems

*Satoshi Ishikawa[1], Takuya Koike[1] (1.Shimokita geopark promotion council)

[O08-P05] Inspiring geosites and not-inspiring geosites: Case study of the Oga Peninsula-Ogata Geopark

*Norihito Kawamura[1] (1.Faculty of Education and Human Studies, Akita University)

[O08-P06] Are habitats such as fumaroles or areas with heavy snowfall suitable for organisms living in Yuzawa Geopark?
Considering the efficacy of the Geopark Guides with a focus on Yamatanukiran and snow camellia.

*Haruki Takayanagi[1] (1.Yuzawa Geopark Promotion Council)

[O08-P07] **The evaluation of geosites in Sanriku Geopark**

*Sho Nagata[1], Hideo Takagi[2] (1.Waseda University, 2.Department of Earth Science, Faculty of Education and Integrated Arts and Sciences, Waseda University)

[O08-P08] **The nature experience program created by Geopark and National Youth Outdoor Learning Center**

*Takuya Harada[1], Mizuki Kobayashi[1], Ken-ichi Yamada[2], Akiyoshi Adachi[2] (1.Mt. Kurikoma Area Geopark Promotion Committee, 2.National Hanayama Youth Outdoor Learning Center)

[O08-P09] A review of geosites in the Bandaisan Geopark

*Yojiro Taketani[1], Hiroshi Sato[2], Makoto Hasuoka[1] (1.Bandaisan Geopark Council, 2.Mt. Bandai Museum)

[O08-P10] Receiving a Yellow Card: Efforts and Future Actions of Sado Island Geopark

*Yayoi ICHIHASHI[1] (1.Sado Islanad Geopark Promotion Office)

[O08-P11] Method for resetting geosites and their use in Sado Island Geopark

*Takeyoshi SADAKANE[1], Yayoi ICHIHASHI[1], Mituhisa AIDA[1] (1.Sado Island Geopark Promotion Office)

[O08-P12] Look back on the 10 years at the statistical data of the Itoigawa UNESCO Global Geopark

*Takahiko Ogawara[1], Ko Takenouchi[1], Yousuke Ibaraki[1], Takeo Kobayashi[2] (1.Fossa Magna Museum, 2.Itoigawa Geopark Promotion Office)

[O08-P13] Application of terrain representation in Geosite
- Case study in North Ibaraki Geopark Project -

*Go Ishikawa[1], Keiko SUZUKI[1], Mamoru Koarai[2], Rika Imaizumi[3], Naoki Takeda[4] (1.Tokyo Map Research Inc., 2.College of Science, Ibaraki University, 3.Aero Asahi Corp., 4.Association for Promotion of North Ibaraki Geopark Project)

[O08-P14] Evaluation and utilization of 34 geosites in Geopark Chichibu

*Hideo Takagi[1], Satomi Hirose[2] (1.Department of Earth Science, Faculty of Education and Integrated Arts and Sciences, Waseda University, 2.School of Education, Waseda University)

[O08-P16] Aiming for Further Development in Hakone Geopark

Ichiro Murayama[1], Shinobu Katano[1], *Yusuke Okutsu[1] (1.Hakone Geopark Promotion Council)

[O08-P17] Citizen Science Forecast and Evaluate Ship and Airplane Operation Success to a Remote Oceanic Island: a case study for Izu-oshima

Kazuhiro Nakamura[2], Juri Hashimoto[1], *Rika Usui[1], Yuichiro Teramoto[1], Kana Nishitani[3] (1.Izu Oshima Geopark Promotion Committee, 2.Former Tokyo Metropolitan Oshima High School Teacher, 3.Corp. Global Sport Club)

[O08-P18] Minami-Alps Geopark Development of programs for education and spread activities

*Eri Ozawa[1], Takahiro Kitahara[1], Airi Karasawa[1] (1.Minami-Alps MTL area Geopark Council)

[O08-P19] Present situation and issues of the Tateyama Kurobe Geoparkafter Yellow card

*Yuta Yamaoka[1], Akira Takeuchi[1], Hajime Iida[2], Kiyoshi Imai[1], Kazuo Kaneko[1], Yukimitsu Shimura[1], Osamu Inamura[3], Tohru Ikurumi[4], Kiichi Imahori[1], Satoshi Kotani[1] (1.Tateyama Kurobe Geopark Society, 2.Tateyama Caldera Sabo Museum, 3.Uozu Aquarium, 4.Lifelong Learning Division, The Board of Education, Kurobe City)

[O08-P20] 1 year survey conducted by Hakusan Tedorigawa Geopark regarding number of pamphlets taken from Roadside station Shirayamasan

*Nakano Kaori[1], Tsuyoshi Hibino[1], Ryoichi Onishi[1] (1.Hakusan Tedorigawa Geopark Promotion Council)

[O08-P21] Promotion of the earth science utilizing the Geopark “Making the stone specimen in Hakusan Tedorigawa Japanese Geopark”

*Yuya Kitoh[1], Satoshi Hirai[1], Kiyofumi Tamamura[1], Tsuyoshi Hibino[2], Kaori Nakano[2], Tomoaki Morishita[3], Yoshihiro Hiramatsu[3], Maki Hamada[3] (1.Ishikawa Geological Survey Association, 2.Hakusan Tedorigawa Geopark Promotion Council, 3.Kanazawa University)

[O08-P22] School Trip from Hong Kong to Dinosaur Valley Fukui Katsuyama Geopark : Challenges and Prospects

*Sumiaki Machi[1] (1.Dinosaur Valley Fukui Katsuyama Geopark Promotion Council)

[O08-P23] Outline of the activities of the Kumano Kodo Ohechi Rangers

*Keishi Jimbo[1] (1.Nanki Kumano Geopark Guide Club)

[O08-P24] Diversity of Nature Activities Related Geodiversity

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[O08-P25] Understanding of regional scientific importance by local Residents – In case of San'in Kaigan UNESCO Global Geopark

*Noritaka Matsubara[1] (1.Graduate School of Regional Resource Management, University of Hyogo)

[O08-P26] Stones forming tombs of feudal lords during Edo period in some geoparks located along the coast of the Sea of Japan

*Tohru Sakiyama[1] (1.Graduate School of Regional Resource Management, University of Hyogo)

[O08-P27] Science Design to make the earth attractive

*Miho Sasaoka[1], Mine-Akiyoshidai Geopark[2] (1.Kochi University / SASAMI-GEO-SCIENCE, Inc., 2.Mine-Akiyoshidai Karst Plateau Geopark)

[O08-P28] 'Be one with the earth; help each other': the Geopark activities of Mine-Akiyoshidai Karst Plateau Geopark

*Hokuto Obara[1], Tomoko Muratani[1], Tristan Gray[1], Kazuhiro Yuhora[2], Koji Wakita[3] (1.Mine-Akiyoshidai Karst Plateau Geopark Promotion Council, 2.Tottori University of Environmental Studies, 3.Yamaguchi University)

[O08-P29] Highlights of Suzaki Coast, Shikoku Seiyo Geopark - Kurosegawa Tectonic Zone, geologic strata of 400 million years ago -

*Chisato Nakamura[1], Tomohiro Tsuji[2], Shikoku Seiyo Geopark Promotion Council [3] (1.NAIBA Co. Ltd., 2.Shikoku Research Institute INC., 3.Seiyo City)

[O08-P30] The Efforts of the Shikoku Seiyo Geopark after the revalidation from JGN council and the 2018 Japan Floods.

*Takumi Sakakiyama[1], Fumito Doi[1], Koshiro Utsunomiya[1], Tsukasa Takahashi[1] (1.Shikoku Seiyo Geopark Promotion Council)

[O08-P31] Method of enjoying relationships with the earth and culture in "the central Shikoku island".

*Azusa Tonotani[1,2], Kana Nakao[1,2], Kazuyoshi Ishii[2], Takuma Asa[3], Soichiro Sagawa[3], Kenshi Nishinari[3], Iori Yamamoto[3], Hisashi Hirao[3], Keiji Nakagawa[3] (1.Miyoshi city office, 2.Geoguides of Miyoshi city, 3.Tokushima prefectural Ikeda high school)

[O08-P32] Bridge of scientific research to school education in a geopark, using a research fund of Muroto UNESCO Geopark

*Takeyuki Ueki[1] (1.Faculty of Risk and Crisis Management, Chiba Institute of Science)

[O08-P33] New basic philosophy of Unzen Volcanic Area UNESCO Global Geopark made in union with local residents and government officers.

*Taku MORIMOTO[1], Marekazu OHNO[1] (1.Unzen Volcanic Area Geopark Promotion Office)

[O08-P34] Evaluation of explanation panels settling at geopark's sites – case study of the explanation panel at a memorial park of houses destroyed by debris flows in Unzen Volcanic Area UNESCO Global Geopark, Japan

Sean OTA[1], Shion MORIKITA[1], Kuumu ONIDUKA[1], Tatsuya MORITA[1], Kenshin OSHIMA[1], Yui KURITA[1], Miyu KAWAZOE[1], Toshiki HIGASHIUCHI[2], Hiroaki OSAKO[2], *Marekazu OHNO[3] (1.Glocal Course, Nagasaki Prefecture Koka High School, 2.Nagasaki Prefecture Koka High School, 3.Unzen Volcanic Area Geopark Promotion Office)

[O08-P35] ESD-SDGs Promotion Model Development utilizing Geoparks including the basic research on the contents of educational programs in Geoparks in Japan

Katsuhiko Asahi[1], Yayoi Ichihasi[1], Takahiko Ogawara[1], Shinobu Katano[1], Ken'ichi Kurihara[1], *Suzuka Koriyama[1], Takeo Kobayashi[1], kei Shimomura[1], Yusuke Suzuki[1], Ko Takenouchi[1], Tsuyoshi Hibino[1], Jun Fujishima[1], Kana Furusawa[1], Yu Horiuchi[1], Emiko Mizuno[1], Ko Miyama[1], Yuta Yamaoka[1], Tamami Yamaguchi[1], Yukiko Yamasaki[1], Ryuta Yamamoto[1], Hikaru Yokoyama[1] (1.Japanese Geoparks Network)

An analysis of the implementation of Mikasa Geopark`s experienced-based GeoTour and its impacts on recruitment and changes in the participant population.

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Mikasa Geopark, located in the center of Hokkaido, joined the Japanese Geopark Network (JGN) in 2013.

Since joining JGN, Mikasa Geopark has focused its efforts on carrying out various experience-based GeoTours.

In recent years, the number of kindergarten and pre-k participants has risen sharply. Mikasa Geopark is successfully achieving its goal of merging geology, and people in a way that appeals to all ages.

The information about GeoTours that appears in this announcement was attained via surveys filled out by participants. The information and the survey results gathered during GeoTour show annual changes across a variety of areas such as participant ages and the number of repeat visitors. Based on these results, we will be conducting further analyses to determine how to improve GeoTours in a way that utilizes of regional history, topography, and the needs of the Geopark as a whole. Going forward, we will be investigating regional opportunities for self-promotion and new activities at the Geopark.

Keywords: GeoTour, Regional Development , MikasaGeopark, GeoHeritage

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Strategy for revaluation and promotion of Toya-Usu UNESCO Global Geopark through SDGs

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Toya-Usu UNESCO Global Geopark is located in the southwestern part of Hokkaido. The whole area of Date City, Toyoura Town, Sobetsu Town and Toyako Town is included in the geopark area. In the area, we have the following program which corresponds to SDGs (Sustainable Development Goals). In "Goal 4: Quality education", promotion of ESD (education for sustainable development) is promoted, and "Goal 11: Sustainable cities and communities" includes reductions of victims in natural disasters, regional comprehensive Disaster risk reduction is included.
The disaster prevention leader "Volcano Meister" qualified in the area has lectures of not only the guided tour of the field study to observe the craters and the disaster remains but also the eruption disaster and the life in the shelter. They also offer courses to learn volcanic activities and disasters using outdoor learning textbooks, hazard maps (volcanic disaster prevention maps), equipment that understands volcanic eruptions. In addition to this, we are implementing initiatives related to the achievement of several SDGs. Regarding these efforts, we will further enhance the contents so that more people can use it.
Geopark is a place where you can enjoy various attractions related to the activities of the earth. At the same time, it is a place where you can think about a sustainable society through concrete examples such as natural disasters. Toya-Usu UNESCO Global Geopark is an area where the practice of reducing disaster education has been continued aiming at co-existence with active volcano which continues eruptions. As a UNESCO World Geopark, we will continue to enhance regional education and to promote information dissemination for domestic and overseas as well as improve tourist and trainee acceptance. In this presentation, we will introduce specific measures for that.

Keywords: Geopark, Disaster Risk Reduction Education, SDGs, ESD

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Examination of the way to convey geo diversity of Mt. Apoi Geopark - Through efforts of geo tour outside the geopark area -

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Examination of the way to convey geo diversity of Mt. Apoi Geopark - Through efforts of geo tour outside the geopark area -

Keywords: plate tectonics, geopark, Mt. Apoi, geotourism, geodiversity, Hidaka mountain

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Geosite Cleanup Activities Leading to Solutions for Global Environmental Problems

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The Shimokita area is surrounded by three seas: the Tsugaru Strait, the Pacific Ocean, and Mutsu Bay. The differing characteristics of these seas bring both grace and harm to the area. Various fish are caught in these seas due to differences in the geological features of their sea floors as well as their ocean currents: the Tsushima Current, which flows northward in the Sea of Japan, and the Oyashio Current, which flows southward in the Pacific Ocean. These currents also cause a variety of items to be washed ashore. Once, strange items found washed up along the beach lead to the creation of indigenous religions. Now however, the large amount of sea garbage that collects here is part of a global problem to be solved. People in Shimokita work on global environmental problems through local activities. Local citizens clean the beaches regularly, and some hosted an exhibition of art made from garbage to raise awareness about the problem of marine debris. The Shimokita Geopark Promotion Council also holds advertising campaigns and collaborative events to increase local interest and participation. These activities have increased awareness of both global environmental problems as well as one of the Sustainable Development Goals (SDG), ” Life Below Water.” The promotion of Shimokita Geopark's theme, “Living with Oceans on the Axe-shaped Land,” by the activities of local citizens has inspired other Geoparks to address marine environmental problems and work toward solving them.

Keywords: Shimokita geopark, cleanup activity, global environmental problem

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Inspiring geosites and not-inspiring geosites: Case study of the Oga Peninsula-Ogata Geopark

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The speaker analyzed protocols spoken by the trainee for the Geopark guide in Oga Peninsula –Ogata Geopark. In the question and answer sessions during the training program, response types shown by the trainees are classified into two types; getting knowledge type and no response type. At the geosites showing only something, e.g. fossils, the trainees would ask about something. Hence, the learners show almost nothing at the geosites requiring some cognition to understand. Finally, the speaker insists that geopark guides should choice better instructional method, depending on the visitors' readiness regarding geoscience concepts.

Keywords: geocognition, geopark guide

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Are habitats such as fumaroles or areas with heavy snowfall suitable for organisms living in Yuzawa Geopark? Considering the efficacy of the Geopark Guides with a focus on Yamatanukiran and snow camellia.

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1. Yuzawa Geopark Promotion Council

Outline
The biodiversity of Yuzawa Geopark is derived from its unique geodiversity, which includes abundant geothermal activity and heavy snowfall. For example, almost no organisms can persist in the vicinity of the Kawaragejigoku-fumarole, which is a geoformation formed by geothermal activity, snow, and rain water, due to the effect of hydrogen sulfide gas. One exception is the dominant and rare species Yamatanukiran (*Carex angustisquama*). The heavy snowfall in the geopark affects the distribution of snow camellia (*Camellia rusticana*), which has supple branches than can withstand heavy snows. In general, Yamatanukiran and snow camellia are found in acidic soils, such as those located near fumaroles (Tsujimura 1982), or along the land of the Japan Sea side (Sakai 1977). The distributions of these two species reflect key characteristics of this unique region.
Typically, two primary reasons are cited for the observed distributions of these two species: 1) that these species merely prefer these environments and/or 2) that their growth is adapted only to this environment. However, we suspect that such explanations are flawed and/or lack a solid foundation. At first glance, the growth of the two species appears to be adequate at their current locations. Neither species requires the existence of fumaroles or heavy snow, given that Yamatanukiran thrives in agricultural soils (Yuzawa Municipal Sukawa Junior High School, 2011) and that snow camellia is bred at botanical gardens on the Pacific side of Japan (e.g., Koishikawa Botanical Garden, 2019). Yuzawa Municipal Sukawa Junior High School (2011) suggested that the growth rate of Yamatanukiran improves as pH approaches neutrality, and as the distance between individual plants and fumaroles increases. In other words, the influence of soil acidification near fumaroles does not promote the growth of Yamatanukiran but instead inhibits it. Therefore, the fumarole has an overall negative effect on the success of Yamatanukiran. Regarding snow camellia, this species almost certainly experiences damage from avalanches or heavy snow. Based on the above information, we concluded that the restricted distributions of these two species represent their response to strong negative effects rather than being a consequence of fumarole and heavy snowfall environments.
Clearly, in the geopark, as-yet-unknown factors have relegated the two species to inadequate environments.
We refer to plausible reproductive interference [interspecific interactions between closely related species (Takakura and Nishida 2018), e.g., *C. angustisquama* with the widely distributed species, *Carex podogyna* (Fujiwara1997); and *C. rusticana* with a species found along the land of Pacific side of Japan, *Camellia japonica* (Sakai1977)] as the primary factor limiting the biodistribution of the two species, as well as to problems with the academic credibility of the Geopark Guides.

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Keywords: reproductive interference, biogeography, interspecific interactions

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The evaluation of geosites in Sanriku Geopark

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The Sanriku Geopark is the largest national geopark in Japan and involves geodiversity and also remains of repeated Tsunami disasters. It was established in 2013 after the big Tsunami disaster in March 2011. Its geopark status was extended after the review in 2017, however, the result was "yellow card" (next requalification within 2 years), therefore the next review will be scheduled in 2019. The purpose of this study is to evaluate geosites selected from the perspective of various values, highlight their advantages and issues to be considered, and finally contribute to the management of the Sanriku Geopark through presenting this study. In order to attain this purpose, research has been conducted for 65 geosites from 48 areas (previous geosites). They are assessed from the perspective of six main values; educational value, scientific value, tourism value, safety and accessibility, conservation and site sustainability, and value of tourism information (Suzuki and Takagi, 2017). After showing advantage and issues to be considered for each geosites, this study lists up various problems to be considered and presents ways to make the Sanriku Geopark more attractive for many tourists.
Reference: Suzuki, D. A. and Takagi, H., 2017, Geoheritage, 10, 123-135.

Keywords: geosite, evaluation, geopark, Sanriku Geopark

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The nature experience program created by Geopark and National Youth Outdoor Learning Center

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The program called “*Children’s Environment Exploration Corps*” gets to experience nature and aims to promote environmental education. Currently, under the cooperation Mt. Kurikoma Area Geopark and Sanriku Geopark, we are developing content that aims at various ways of enjoying nature and their understanding. In this report, we will introduce the contents and outcomes of 4 activities held since 2017.

In the Sanriku edition, we learned the features and difference of nature and culture of the sea and the land through on-site inspection and experience activities.

In the Mt. Kurikoma Area edition, we learned about various nature and culture spreading on the Mt. Kurikoma Area Geopark through various experience activities.

With the involvement of geoparks, we were able to incorporate new perspectives such as knowledge of nature science and connection with nature and life in activity. Also, children who participated in this program learned new perspectives on nature and how to enjoy them, leading to deepening their interest in nature.

Keywords: geopark, environmental education

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A review of geosites in the Bandaisan Geopark

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It has been 7 years since the Bandaisan Geopark was designated as Japan Geopark. We are currently reviewing whether existing geosites in the area are appropriate for the geopark and trying to discover new geosites with geo-guides. Based on the results, we plan to add and remove the public geosites, to progress sustainable conservation of important geosites and to develop geo-tours with new themes.
The geosites of the Bandaisan Geopark have been selected based on the main theme of the geopark, "To deepen understanding of the birth and transition of the Bandai Volcano, in particular, the large-scale changes in the landform and natural environment due to collapses of the mountain body and debris avalanches and to learn about the influence of Mt. Bandai on people's lives and history and formation of the unique culture".
The Oshio area of Kitashiobara-mura in the northwestern part of the Bandaisan Geopark is mainly composed of the Miocene Green Tuff in the Neogene Period and has important outcrops for understanding the geological history of the period. But, because the geology is not directly related to the formation or eruptive activity of the Bandai Volcano, the area has been excluded from geosites and geo-tours in the geopark.
However, studying the geological history of the Neogene Formation, which forms the basis of the Quaternary volcanoes, provides an important opportunity to understand the plate movements, from the birth of Japan Sea through the uplift of the earth to the formation of Quaternary volcanoes. In addition, there is the Oshio hot spring in the Oshio area, which is visited by many tourists. Salt purified from the hot spring water was an important local resource supplied to the Aizu clan in the Edo period and is even now sold as "mountain salt". The "mountain salt" originates in the seawater of the Green Tuff era, and the role which the heritage of the earth achieved in the history and industry of the region can be shown through a geo-tour. For these reasons, the establishment of new geosites in the Oshio area can be attractive and significant for the geopark.
We will attempt a tour around the newly selected geosites in the Oshio area as the "Geology Day Tour" in 2019 and examine the effects and significance of the tour. Based on the results, we hope to provide a geo-tour with the story for visitors.

Keywords: Bandaisan Geopark, geosite, Oshio hot spring

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Receiving a Yellow Card: Efforts and Future Actions of Sado Island Geopark

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1. Sado Islanad Geopark Promotion Office

In Autumn 2017, Sado Island Geopark was re-examined by JGC and received a yellow card, requiring necessary action to be taken within a two-year period to qualify as a geopark.
I will state the changes in efforts currently underway and initiatives which Sado Island Geopark envisages to take in the near future.

Keywords: geopark, yellow card, sado island

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Method for resetting geosites and their use in Sado Island Geopark

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1. Sado Island Geopark Promotion Office

In recent years, in geoparks in Japan, a definite policy for the classification and definition of sites has been announced by the Japan Geopark Committee.In Sado Island Geopark, all the places of interest have so far been identified with the term ‘geo point’. On this point, in the evaluation report of Sado Island Geopark of 2017, it was pointed out that it is necessary to reclassify all 237 geo points into the geological sites, natural (ecological) sites and cultural sites, as advocated by the UNESCO Global Geoparks.
Based on this recommendation, we created a ‘comprehensive geosite setting plan’ which contains all criteria and procedures such as how to reclassify the geo points into geosites. We are now working on resetting the 237 geo points as geosites.

Two criteria were established in this above-mentioned plan in order to reset geo points as geosites.
The first criterion is for selecting geosites with geoscientific value from geo points, which include sites which also have natural (ecological) and cultural value besides geological value.
The second criterion is whether selected geosites are suitable for actual utilization. Regarding this actual utilization, we established three categories which are ‘for research’, ‘for learning’ and ‘for general purposes (tourism)’ to classify geosites.
Among the selected geosites, those that fit into all three categories will be introduced on our website and in the brochure, and will also be used for sightseeing.

In this presentation, we will describe the geosite resetting method in Sado Island Geopark, introduce the geosites finally chosen, and discuss the utilization of geosites and the challenges that arise from resetting them.

Keywords: Sado Island, geopark, geotourism, geosite, geological heritage

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Look back on the 10 years at the statistical data of the Itoigawa UNESCO Global Geopark

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1. Fossa Magna Museum, 2. Itoigawa Geopark Promotion Office

Itoigawa was designated a Global Geopark in August 2009 and continues activities as the Itoigawa UNESCO Global Geopark today. This paper is a retrospective of the past 10 years of the Itoigawa Geopark, through analysis of statistical data related to tourist sites and geopark activities.

Itoigawa City first implemented the “Fossa Magna and Regional Development Plan” in 1987 to make use of the region’s geological and topographical heritage for tourist promotion. Itoigawa City’s tourism averaged about 3 million visitors per year between 1997 and 2001, but began a downward trend starting in 2002, decreasing further following the Chuetsu Earthquake (2004) and Chuetsu Oki Earthquake (2007) to only 1.85 million visitors in 2007 (Fig 1). Itoigawa was then recognized as a Japanese Geopark in 2008 and a Global Geopark in 2009, which saw a stop in tourism decline. Coinciding with the opening of the Hokuriku Shinkansen, Itoigawa saw 2.49 million visitors in 2015.

The Fossa Magna Museum is Itoigawa Geopark’s central facility. On its opening year in 1994, the museum saw 95,705 visitors, but this had over halved to 40,683 visitors in 2007 (Fig 2). This can be seen to be a result of not only disasters, but also because the museum’s exhibits had never been updated. Following Geopark certification, the museum saw an increase to nearly 60,000 annual visitors and, following the opening of the Hokuriku Shinkansen and a complete renovation of the museum’s exhibits, the museum saw a record-breaking 101,725 visitors in 2015.

Takanami-no-ike Pond is part of the tourism course which visits the Kotakigawa Jade Gorge, one of Itoigawa’s jade producing gorges and Itoigawa’s representative geosite. After Global Geopark certification in 2009, an increase in bus tours saw a peak of 28,940 visitors in 2012. However, bus tours continue to decrease, with only 17,720 visitors in 2014. There is no regular public transportation to Takanami-no-Ike Pond, so the opening of the Hokuriku Shinkansen had no effect on these numbers, and 2017 saw a continued downward trend with only 14,610 visitors.

Itoigawa Geopark formed the Geopark Tourist Guide Society in 2010. During this first year, the guides led 97 tours of 1770 people. The Hokuriku Shinkansen has increased demand for tours and following the Itoigawa City Station North Fire of 2016, tours of the affected areas are also in demand. In 2017, there were 147 tours of 3,645 people recorded.

The Itoigawa Geopark Certification Exam started in 2009 as a ‘gotochi kentei’ regional certification exam. Such exams are popular in Japan to promote study of local culture and history. The first year, which coincided with Global Geopark Certification, saw 464 testees (Fig 3). Itoigawa Geopark and Hong Kong Geopark share a sister geopark relationship and since 2011 have conducted student exchange programs. Itoigawa Geopark requires that participants pass the first level of Itoigawa Geopark Certifications. For this reason, the number of primary school students taking the test increased from 20 in the first year to 86 in 2011.

Recently, foreign tourism to Japan has been increasing dramatically, and Itoigawa is no exception. 2013

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saw only 154 foreign visitors staying in Itoigawa hotels (Fig 4), but since Geoparks became an official UNESCO Program (2015) and the through promotional efforts including the Itoigawa Seafood Shuttle Bus (2015), these have increased to 2,662 visitors in 2017, an increase even more dramatic than that of nearby cities such as Hakuba.
The Geopark Activities have seen an increase in visitors to the Fossa Magna Museum and foreign visitors, but regions of the Geopark that lack public transportation infrastructure like Takanami-no-Ike Pond continue to see a noteworthy decrease in yearly visitors. Furthermore, projects such as the Hokuriku Shinkansen and Geopark Certification Exam have significant effects, but these effects diminish over time. Further polishing of the region’ s attractiveness and development of new programs and activities are essential.

Keywords: Itoigawa UNESCO Global Geopark, Fossa Magna Museum, Kotakigawa Jade Gorge, Sustainable Development

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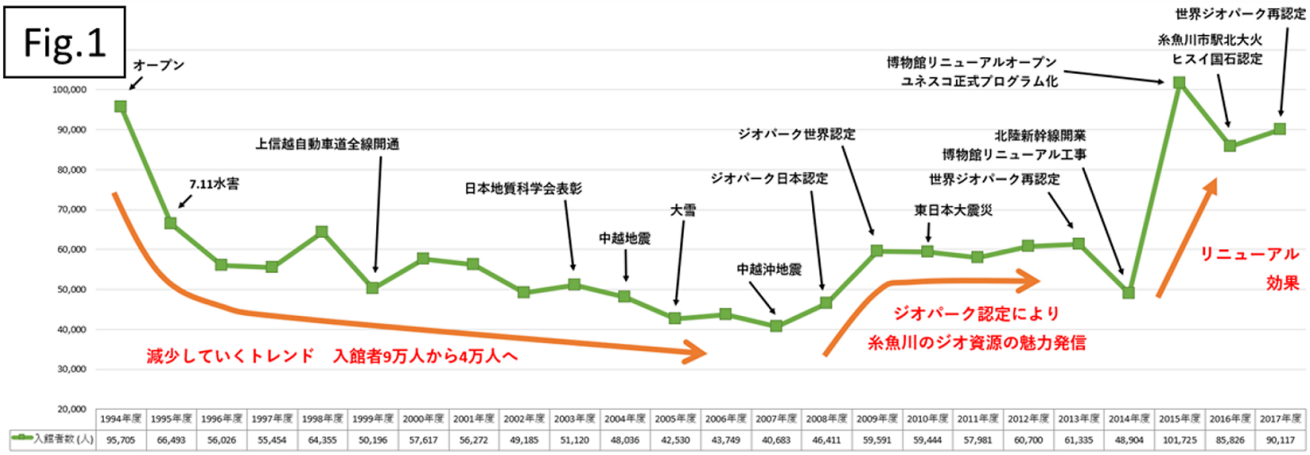
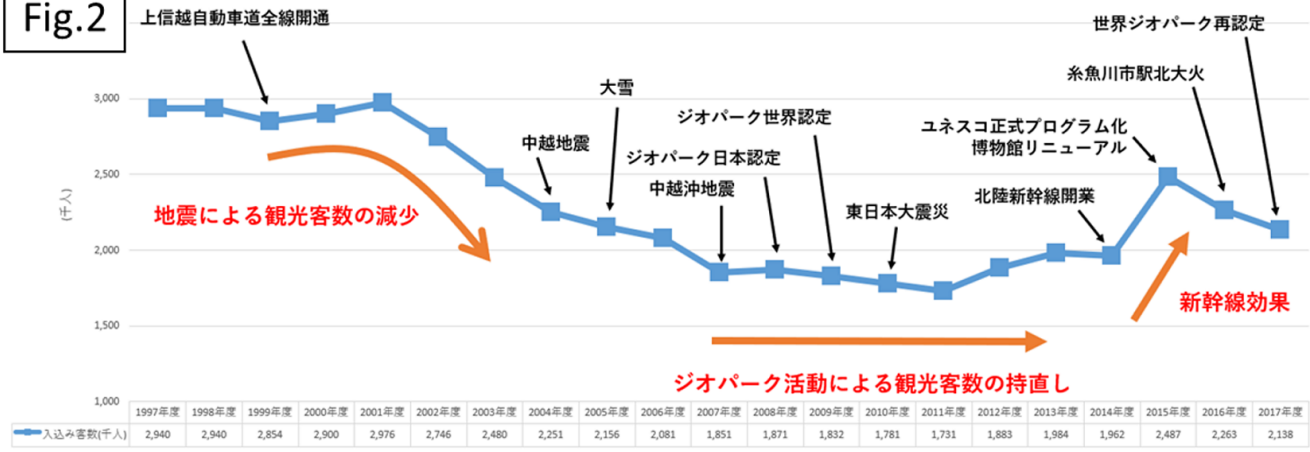
Fig.1



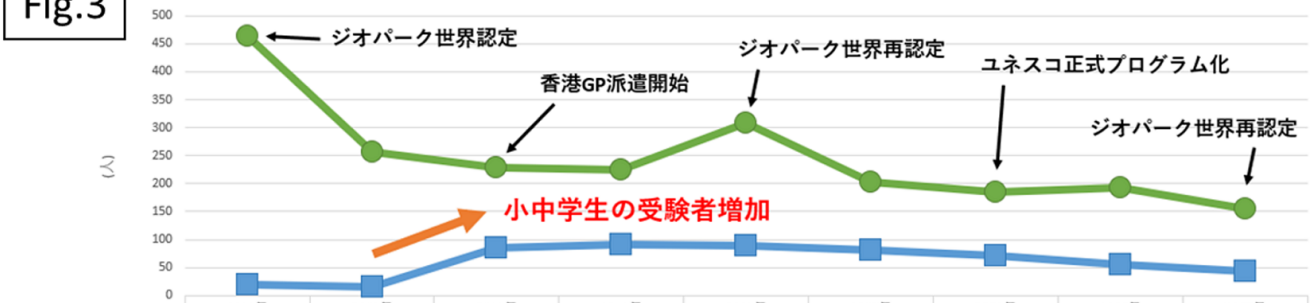
	1994年度	1995年度	1996年度	1997年度	1998年度	1999年度	2000年度	2001年度	2002年度	2003年度	2004年度	2005年度	2006年度	2007年度	2008年度	2009年度	2010年度	2011年度	2012年度	2013年度	2014年度	2015年度	2016年度	2017年度
入館者数(人)	95,705	66,493	56,026	55,454	64,355	50,196	57,617	56,272	49,185	51,120	48,036	42,530	43,749	40,683	46,411	59,591	59,444	57,981	60,700	61,335	48,904	101,725	85,826	90,117

Fig.2



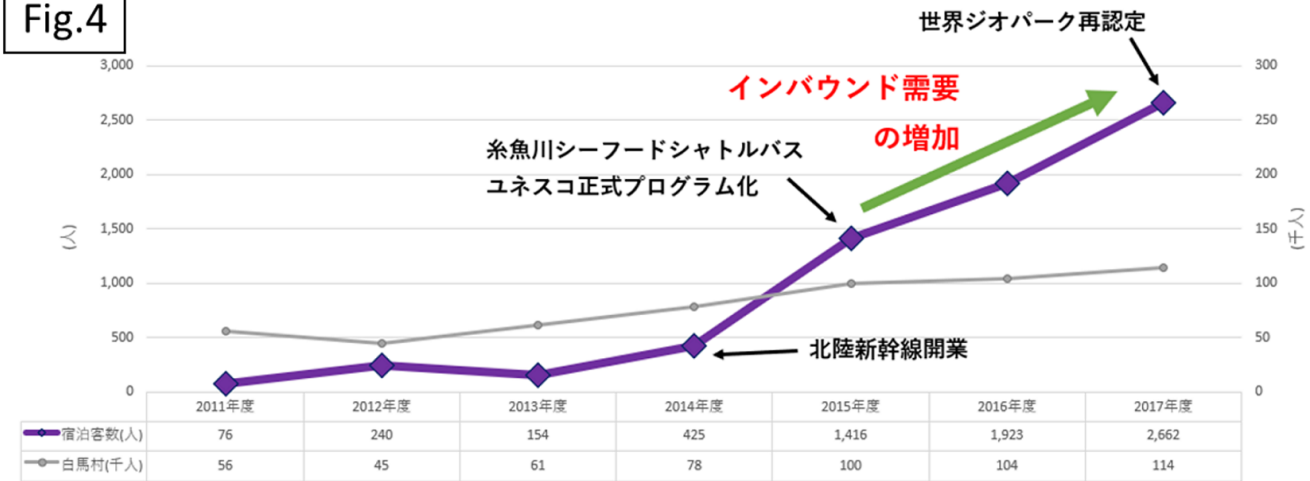
	1997年度	1998年度	1999年度	2000年度	2001年度	2002年度	2003年度	2004年度	2005年度	2006年度	2007年度	2008年度	2009年度	2010年度	2011年度	2012年度	2013年度	2014年度	2015年度	2016年度	2017年度
入込み客数(千人)	2,940	2,940	2,854	2,900	2,976	2,746	2,480	2,251	2,156	2,081	1,851	1,871	1,832	1,781	1,731	1,883	1,984	1,962	2,487	2,263	2,138

Fig.3



	2009年	2010年	2011年	2012年	2013年	2014年	2015年	2016年	2017年
合計受験者数(人)	464	257	229	225	308	202	184	193	155
小中学生受験者数(人)	20	16	86	92	90	81	72	55	43

Fig.4



	2011年度	2012年度	2013年度	2014年度	2015年度	2016年度	2017年度
宿泊客数(人)	76	240	154	425	1,416	1,923	2,662
白馬村(千人)	56	45	61	78	100	104	114

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Application of terrain representation in Geosite - Case study in North Ibaraki Geopark Project -

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Geosites feature the sights of the geopark, which designate sites of spectacular geological feature. It is important to make it have corrected geological information and easily to understand. Most geopark use flyers, but only a few have topographic map.
In the Japanese Geoparks re-certification activity, North Ibaraki Geopark Project has the Geosite pamphlet with map illustration. It's customized and approachable but hard to match with the on-site. To design the new pamphlet, we used **New Relief Map created with Multiple Light Source (DecoBocoChizu Premium)** based on the 5m DEM (Digital Elevation Model). The new Geosite maps show more reality and much easier to recognize the geological feature such as marine terrace, river terrace and fault. Furthermore, overlapping the shadow graph and geologic graph can get the geographic structures.

*: This research is supported by Ibaraki University Geological Information Utilizing Project and KAKENHI (16K01213).

Keywords: Relief Map created with Multiple Light Source, North Ibaraki Geopark Project, terrain representation

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Evaluation and utilization of 34 geosites in Geopark Chichibu

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The Geopark Chichibu was established in 2011 as a national geopark of Japan, and its geopark status was extended after the review in 2015. Next review is scheduled to be conducted in 2019. Geopark Chichibu is claimed to be the birthplace of modern Japanese geology due to its geodiversity since the Meiji era. The purpose of this study is to evaluate 34 new geosites (Inoue and Tomita, 2018) of the Geopark Chichibu from the perspective of various values, highlight their advantages and issues to be considered, and finally contribute to the management of the Geopark Chichibu through presenting this study. In order to attain the above purpose, research has been conducted for 34 (this number is important because of the 34 pilgrimage sites (temples) in Chichibu) new geosites proposed in July, 2018, and additional 5 possible geosites. Total 39 geosite candidates are assessed from the perspective of six main values; educational value, scientific value, tourism value, safety and accessibility, conservation and site sustainability, and value of tourism information (Suzuki and Takagi, 2017). After showing advantage and issues to be considered for each geosites, this study proposes a partial change of new geosite from the perspective of geotourism as well as ways to make the Geopark Chichibu more attractive for many tourists.
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Keywords: Geopark Chichibu, evaluation of geosites, geotourism

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Aiming for Further Development in Hakone Geopark

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1. Hakone Geopark Promotion Council

Hakone Geopark consists of 2 cities and 3 towns, Hakone Town, Odawara City, Manazuru Town, Yugawara Town and Minamiashigara City, were at first, consisted by 1 city and 3 towns and were authorized by Japanese Geoparks in 2012. After the authorization, there was an increasing momentum to join us in Minamiashigara City, and in 2015, MInamiashigara City, Minamiashigara-Geoguide Association and other related company joined the council. With this new material, we passed the new authorized examination in 2016.

Due to this addition, 8 new geosites were added. For example, at Mt. Yaguratake, a very new rock formation in the world, you can experience the dynamic earth movements of the Ashigara group, which joined the mainland by the collision between the plates. Also Ashigara road which has a history that is older than Tokaido has been added.
Theme of the Hakone Geopark can be understood by studying the geosites. it produced further depth and expanse in Hakone Geopark’ s theme and story.

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Citizen Science Forecast and Evaluate Ship and Airplane Operation Success to a Remote Oceanic Island: a case study for Izu-oshima

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1. Izu Oshima Geopark Promotion Committee, 2. Former Tokyo Metropolitan Oshima High School Teacher, 3. Corp. Global Sport Club

Weather outlook and forecast of ship and airplane operation are invaluable information for daily life in remote islands, but also for tourism and business on those islands. In order to help a local island community, a web site was opened in 2004 to provide an outlook for week-term ship and airplane operation between Tokyo and Izu-oshima and annual report evaluating outlook success ratio for better understandings of nature and climate of Izu-oshima. In collaboration with Izu-shima Geopark, we analyze and discuss a long-term outlook success from 2004 to 2018 for promoting and implementing geo- and eco- tour operation in good, convenient and comfortable seasons of the year.

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Minami-Alps Geopark Development of programs for education and spread activities

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1. Minami-Alps MTL area Geopark Council

In order to know and enjoy the Geopark more deeply, it is effective to listen to the story of the guide by actually looking at the site. However, I think that people who do not know Geopark suddenly participate in geotour etc. are high hurdles.
So, at the Minami-Alps Geopark, we developed a program that allows you to feel free to participate as a catalyst for getting to know the Geopark. And we have been using it in workshop at community center and events. We are also discussing prior learning of educational tour intended for elementary school students' and utilization as rainy day program.
In this presentation, we introduce the mainly about newly developed program and the situation of the use.

Keywords: Geopark, Education

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Present situation and issues of the Tateyama Kurobe Geopark after Yellow card

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1. Tateyama Kurobe Geopark Society, 2. Tateyama Caldera Sabo Museum, 3. Uozu Aquarium, 4. Lifelong Learning Division, The Board of Education, Kurobe City

Tateyama Kurobe Geopark is a Japanese Geopark composed of 9 municipalities in eastern Toyama prefecture and a part of Toyama bay. The features of our Geopark are 4000 meters difference in elevation from the top of Tateyama mountain range with 3000 meters above sea level to the Toyama Bay with depth 1000 meters. Our Geopark was proposed by mainly researchers. The management organization was established by local businesspersons and supported by local governments. Therefore, it is a unique Geopark in Japan that is operated by NGO. Tateyama Kurobe Geopark is operated in cooperation with municipalities, universities and museums. In recent years, more local people, companies and private groups are active about Geopark. The role of Geopark in the region is gradually increasing. However, the result of the Japanese Geoparks revalidation process in 2018 was Yellow card (conditions attached). The main indications are four points as follows (1) difference in recognition about Geopark among participant in Geopark activities, (2) conservation plan and conservation activities are unclear, (3) lack of visibility in major tourist routes and few Geopark signs, (4) difficult explanation. We make and fulfill an improvement plan getting advices from the Japanese Geopark Committee. In this paper, we report activities and issues of the Tateyama Kurobe Geopark considering the results of the revalidation process.

Keywords: Tateyama Kurobe Geopark, Geopark, Conservation, Tourism, Education

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1 year survey conducted by Hakusan Tedorigawa Geopark regarding number of pamphlets taken from Roadside station Shirayamasan

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1. Hakusan Tedorigawa Geopark Promotion Council

Tourism is one of the very important initiatives being focused on by the geopark. Tourism at its core can be thought of as many people visiting a certain area. Also pamphlets exist as a tool able to increase the number of visitors. In recent years the principal means of sharing information has become electronic devices, however conveying information through printed mediums is still effective.
At the Hakusan Tedorigawa Geopark Promotion Council, in order to understand which size and design of pamphlet will catch the customer’ s eye, in January 2018 we started monitoring the number of national geopark regional pamphlets being taken from the roadside station Shirayamasan. When we make future pamphlets this information should allow us to create a pamphlet which both entices customers to take the pamphlet home as well convey the charms of the region.
The roadside station Shirayamasan is located alongside Japan National Route 157, connecting the flatland with the Mt. Hakusan foothills. This roadside station is the entrance gate to the route leading from Ishikawa Prefecture, through the foothills of Mt. Hakusan and onto Fukui and Gifu Prefectures. There is no public transportation such as trains or buses assigned to this route and the roadside station does not currently offer popular services such as restaurants and souvenir shops. Due to this the vast majority of users come by car or bicycle with their main purpose being a brief rest. However, we do not have any information regarding the age, gender, occupation, social status or reason for taking the pamphlets home.
As a result of the monitoring, there was no particular connection found between the number of pamphlets taken last month and the design of the pamphlets or their positioning within the roadside station. However what we did notice was that the season strongly influences the number of people who take pamphlets home. The period over GW (Golden Week –series of national holidays in May), the summer holiday period as well as the popular autumn leaves period saw an increase in the number of pamphlets being taken home. This concludes my report after one year of monitoring the number of pamphlets being taken from the roadside station Shirayamasan.

Keywords: pamphlet, tourism, Hakusan Tedorigawa Geopark, roadside station, public awareness

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Promotion of the earth science utilizing the Geopark “Making the stone specimen in Hakusan Tedorigawa Japanese Geopark”

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In recent years, due to the declining birthrate, aging of society, and fewer interests of science, new leaders in the field of the natural science has been decreasing. On the other hand, extreme weather with severe damages has increased in recent years. Therefore, it is necessary to develop human resources not only of researchers and engineers with interests of natural science but also of citizens with understanding and knowledge of natural environment.
The Ishikawa Geological Survey Association, the Hakusan Tedorigawa Geopark Promotion Council, and Kanazawa University have organized the event entitled “Making the stone specimen in Hakusan Tedorigawa Japanese Geopark" for elementary school students and their parents since 2017. This event utilizes a field of the Geopark, aiming to make children, as the next generation, have interests in nature and natural science through activities in the field.
On Saturday 20 October 2018, the 35 pairs of children over fourth grade in elementary school and their parents selected by lottery participated joined the event. After learning stones, formation processes of those and how to distinguish them, they collected stones and made the stone specimens with Japanese and foreign students and others using hammers, loupes, and medicinal liquids. From the results of the questionnaire answered by the children after the event, we recognize that the children showed the high curiosity of the stone and the nature, experienced the difficulty and the pleasure of learning the nature. Based on the questionnaire, we verify the learning level of the contents and the explanation of the activity and reflect it in future activities. We are planning to continue this event, as well as trying new attempts to tackle the curiosity of children.

Keywords: New leaders, Geopark, Education, Natural disaster, Field study, Questionnaire

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School Trip from Hong Kong to Dinosaur Valley Fukui Katsuyama Geopark : Challenges and Prospects

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1. Dinosaur Valley Fukui Katsuyama Geopark Promotion Council

Dinosaur Valley Fukui Katsuyama Geopark is located at mountainous region, Fukui Prefecture, Japan. As you can understand from the name of geopark, the region is famous for dinosaur fossils excavation. 5 named dinosaurs have been discovered from Tetori group (early Cretaceous) so far (Azuma & Currie, 2000; Kobayashi & Azuma, 2003; Azuma & Shibata, 2010; Shibata & Azuma, 2015; Azuma et al., 2016). And there are various beautiful landscapes, formed by old volcanic activities and river flows (Kuzuryu rive and its branches).
Fukui Prefectural Dinosaur Museum is very famous in Japan and probably there are many visitors for school trip every year. However, most of them visit there and leave Katsuyama. This has been an old problem of Katsuyama city since the museum was established. We accepted school trip from Hong Kong Chinese Women's Club Fung Yiu King Middle School. We report challenges and prospects about accepting the students trip and guiding them.

Keywords: Dinosauar Valley Fukui Katsuyama Geopark, school trip, Hong Kong UNESCO Global Geopark

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Outline of the activities of the Kumano Kodo Ohechi Rangers

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1. Nanki Kumano Geopark Guide Club

Outline of the activities of the Kumano Kodo Ohechi Rangers

In this poster we will report about the activities of the Kumano Kodo Ohechi Rangers and the relationship between the Nanki Kumano geopark.

The Kumano Kodo Ohechi Rangers was formed in 2004.

The Ohechi route of Kumano Kodo has few flatlands around the coast.

As a result, due to modern traffic improvement many roads of the Ohechi route were duplicated, traces of which were lost.

Volunteers to conduct the exploratory activities of the Ohechi route have gathered, and the Kumano Kodo OhechiRangers is formed.

Search activity is to listen from old people and learn from old maps, investigate the route, rediscover the way.

The exploring activity of the Kumano Kodo Ohechi Rangers revealed about 120 km of the large side route from Tanabe City to Nachikatsura Town, and in 2017 the addition of some part of Ohechito the World Cultural Heritage "Sacred Sites and Pilgrimage Routes in the Kii Mountain Range" was confirmed.

In the vicinity of the Ohechi Route, many of the members of the Kumano Kodo Ohechi Rangers where the major geosites of the Nanki Kumano Geopark are dotted have completed the geopark guide training course and are conducting guide activities.

Also, it is also an area of Yoshino Kumano National Park, and some have registered as a natural park instructor.

Members are actively engaged in the creation of illustration maps, the setting of signposts, the implementation of walking in cooperation with tourism associations and travel agencies, and the conservation activities at local school classes.

I will examine what kind of activities are needed in the future.

Keywords: Geopark, Kumanokodo, maintenance

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Diversity of Nature Activities Related Geodiversity

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1. Sanin Kaigan Geopark Promotion Council, 2. SGAR, 3. Graduate School of Regional Resource Management, University of Hyogo

San’in Kaigan UNESCO Global Geopark is the area stretching from Kyotango City in Kyoto Prefecture; Toyooka City, Kami Town and Shin’onsen Town in Hyogo Prefecture; and Iwami Town and northern part of Tottori City in Tottori Prefecture.

Geopark theme is ‘Geological features, natural environment, people’s lives and the formation of the Sea of Japan.’

There are many organizations which conduct outdoor activities in San’in Kaigan Geopark area. More than 20 bodies in 3 prefectures offer variety of activity programs, making good use of the geological characteristics of the area including the seas (sea kayaking, snorkeling, diving), mountains (mountainous area cycling, treeing), snows (skiing, showshoe), sand dunes (sand board) and rocks (lava trekking).

Each activities need suitable geological features. Diverse activities mean that there are diverse geological features in San’in Kaigan Geopark. In this presentation, I’ll talk about the relationships between variety of activities and the geological features in San’in Kaigan Geopark.

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Understanding of regional scientific importance by local Residents –In case of San’ in Kaigan UNESCO Global Geopark

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Regional self-support is very important things in local community. And one of the important roles of geopark activities is resident understanding of the regional scientific importance and features. UNESCO Global Geoparks give international recognition for sites that promote the importance and significance of protecting the Earth's geodiversity through actively engaging with the local communities. For this purpose, it is important that local residents participate in geopark activities positively. However, it is difficult for local residents to understand regional scientific importance and local geological phenomena.
So, we started “geo-communication” with local people. For example, we created “Geopark foot pass” and “geopark walking map” in cooperation with local people, to promote better understanding and communication with local people, government and academia involved in geopark activities. Local residents could understand geological features through this activity. In this poster, I would like to introduce our “geo-communication” activities.

Keywords: geopark, geo-communication, earth's phenomenon

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Stones forming tombs of feudal lords during Edo period in some geoparks located along the coast of the Sea of Japan

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San’in Kaigan Geopark, Shimane Peninsula and Shinjiko Nakaumi estuary Geopark, and Hagi Geopark are located along the coastal area of Sea of Japan and each has feudal load tombs of the generations. I show the characteristics and speculate the production area of the stones, in the basis of petrography and magnetic susceptibility. Grave site of Ikeda family who are feudal loads of Tottori Domain situate in the San’in Kaigan UNESCO Global Geopark. Most of the tombs in the grave site are made by Mochigase Granite with low magnetic susceptibility located in the south of Tottori City. Stones of tombs in the grave site of Matsudaira family who are feudal loads of Matsu Domain in the Shimane Penninsula and Shinjiko Nakaumi estuary Geopark are clearly divided to older and younger tombs. Former is made of coarse-grained biotite granite with low magnetic susceptibility and latter is made of medium-grained hornblende biotite granodiorite with high magnetic susceptibility. Former ones may be quarried from Seto Inland Sea area and latter ones may be the granite from local area in San’in Zone. Granitic tombs in the Hagi Geopark have also similar tendency.

Keywords: granite, geopark, stone material, magnetic susceptibility

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Science Design to make the earth attractive

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Geoparks goes beyond just the science framework. I think that how geoparks are expected to show relationship earth and people's livelihood of the future and the past in each area.

In order to attract the public, it will be necessary to establish diverse entrances to diverse people.

In this presentation, from the viewpoint of science design, I would like to have the opportunity to think about the future activities of Geopark together, and introducing the completely new efforts I have been doing to the public in general.

Keywords: science design, diverse perspectives

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‘Be one with the earth; help each other’: the Geopark activities of Mine-Akiyoshidai Karst Plateau Geopark

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1. Mine-Akiyoshidai Karst Plateau Geopark Promotion Council, 2. Tottori University of Environmental Studies, 3. Yamaguchi University

In Mine-Akiyoshidai Karst Plateau Geopark, our every activity is conducted under the concept of ‘be one with the earth; help each other’. Through the conservation and utilisation of the earth’s geological heritage, these activities work towards the realisation of the Sustainable Development Goals, which exist for the purpose of achieving UNESCO’s core principle of building peace in the hearts of men and women. This presentation will explain what this concept means in reality, and will introduce the activities already put into practice and plans to be executed in the future in Mine-Akiyoshidai Karst Plateau Geopark, as we look towards achieving UNESCO Global Geopark status.

Keywords: Mine-Akiyoshidai Karst Plateau Geopark, Japanese Geoparks, geopark activity, Sustainable Development Goals

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Highlights of Suzaki Coast, Shikoku Seiyo Geopark - Kurosegawa Tectonic Zone, geologic strata of 400 million years ago -

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1. NAIBA Co. Ltd., 2. Shikoku Research Institute INC., 3. Seiyo City

Kurosegawa tectonic zone is composed mainly of rocks of the continental crust and strata deposited in shallow seas around the continent. It has been assumed that the fragments which has been divided from the supercontinent Pangea near the equator collided with another continent. Suzaki coast is one of the main geological sites of Shikoku Seiyo Geopark in Ehime Prefecture. It is the only location in Japan where the strata of acidic tuff belong to the Kurosegawa tectonic zone crops out continuously for 300 m. The acidic tuff was inclined vertically, creating fantastic landscape. In addition, there are outcrops of tuff breccia and intrusive rocks which are closely related with the acidic tuff. We introduce the highlights of Suzaki coast and explain how these strata were formed.

Acidic tuff: The acidic tuff layer constituted of alternation of muddy and sandy beds. Various sedimentary structures, such as grading, load structure and convolution, those are characteristic in turbidites were formed in the acidic tuff. As showed by Makisaka and Kato (1983), upper direction of the strata faces to the northeast. The acidic tuff includes coarse tephric particles of feldspar, suggesting that it deposited the sea close to continental or volcanic arc. The acidic tuff deposit of 300 m-thick suggests that there was stably volcanic activity over a prolonged period. It is implied that the sedimentary environment of the strata was the sea close to the volcano of the continent. The acidic tuff yields well-preserved radiolarian fossils. Further identification of the radiolarian fossils could contribute to estimate the ages of the sedimentation and the volcanic activity.

Tuff breccia: Tuff breccia including coral fossils overlies unconformably on the acidic tuff with the obvious boundary. The tuff breccia is poorly sorted, and reverse-grading is observed at the bottom of the tuff breccia. Those findings indicate that it is a debris flow deposit formed by the sector collapse or the submarine sliding, and it is presumed that they flowed into the deeper ocean floor.

Intrusive rock: We can see the intrusive rocks at several localities. They cut lamination of the tuff layer and are fine-grained and has massive and homogeneous texture. Since the existence of intrusive rock implies that volcanic activity took place at the site where the acidic tuff deposited, more detailed work is necessary.

On the Suzaki Coast, we can see how the acidic tuff accumulated in the sea close to the continental or the volcanic arc. The Suzaki coast is an academically important place to elucidate the geological history of the Japanese islands and it is also an attractive geological site for the ordinary visitors. Finally, we also introduce how to tour around geological spots in Suzaki coast on the presentation.

Keywords: Shikoku Seiyo Geopark, Kurosegawa tectonic zone, acidic tuff, intrusive rock, debris flow deposit, radiolarian fossil

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The Efforts of the Shikoku Seiyo Geopark after the revalidation from JGN council and the 2018 Japan Floods.

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1. Shikoku Seiyo Geopark Promotion Council

On December 22, 2017, Japanese Geopark Network Council granted the renewal certified status to our Shikoku Seiyo Geopark for another four years. Although we were actively involved in geopark activities after getting the approval of renewal certificate, we had experience of several severe damages due to heavy rain, landslides, and floods in Seiyo City in 2018, and which caused the loss of six people’ s lives. In the Shikoku Seiyo Geopark, the five geosites were damaged among twenty-three sites. The two geosites are still in the state of restricting to the visitors to access for the entry up until now.

In order to respond to the situation, we conducted the educational programs named “Seiyo Nature and Culture College” to the people living around the areas for the awareness of their surroundings. In the programs, we conducted lectures and field trip programs with experts who are familiar with local knowledge and geography, train new courses, and teach the participants how to use the geopark. The participants in the field trips had joyful experience of watching the scenery of the areas familiar from usual as they listened to the commentaries from the experts. In cooperation with school education, we offered the school tours to affected geosites as the annual education program of learning about the geopark.

To improve the indicated matter of revalidation, we are seeking a geopark story that makes visitors interested in the last year. Not only each working committee and geoguides have shared the keywords, but also the participants in the educational programs have taken the discussions. In addition to that, our council have supported the collaborations with local industry and commerce for the preparation for the Shikoku Seiyo Geopark guidebook, establishment of promotion shops, and branding new special products. On the other hand, we also have some challenges of dealing with both disaster response and geopark promotion. For the future, we are going to share the issue in JGN and make the opportunity to learn our lands how it was formed by using new educational material of disaster prevention.

Keywords: Geopark, Seiyo City, revalidation, 2018 Japan floods

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Method of enjoying relationships with the earth and culture in "the central Shikoku island".

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1. Miyoshi city office, 2. Geoguides of Miyoshi city, 3. Tokushima prefectural Ikeda high school

Miyoshi city in Tokushima prefecture is called "the central Shikoku island", which consists of "Sora" and "Machi" area. In the Sora area, villages are scattered on the gentle slopes that are formed by landslides in Shikoku mountains and Sanuki mountain range, and there we can find various creative solutions for living on such landforms in agriculture, architecture and customs. On the other hand, in the Machi area people live on river terraces made by the Yoshino river or on the ground formed by activities of the Median Tectonic Line, where the shredded tabaco industry and water transportation business were prosperous utilizing the Yoshino river.
As stated above, we, Miyoshi city, who has deep relationships with the earth and culture, are promoting activities aiming for the Japanese Geopark certification. We are doing the "Geotours" as one of efforts that have tourists and local people enjoy relationships with the earth and culture.
In this presentation, we introduce four types of the Geotours; by 1) Geologist, 2) Staff in Geopark plan, 3) Geoguide, 4) High school student.

Keywords: Geotour, Median Techtonic Line

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Bridge of scientific research to school education in a geopark, using a research fund of Muroto UNESCO Geopark

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Activities in a geopark is composed of conservation, education and tourism, in ascending order. Scientific research is mainly related to conservation, with little contribution to school education. Drilling survey was performed on the school ground, using a research fund of Muroto UNESCO Geopark. In the field, students observed a drilling work and enjoyed small excursion around. In the laboratory, students cut a sediment core, observed facies and imagined paleoenvironment. This presentation reports a bridge of scientific research to school education in a geopark.

Keywords: bridge, scientific research, school education, research fund, drilling survey

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New basic philosophy of Unzen Volcanic Area UNESCO Global Geopark made in union with local residents and government officers.

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1. Unzen Volcanic Area Geopark Promotion Office

1. Revision of a basic philosophy's of The Council of Unzen Volcanic Area Geopark.

The basic philosophy of Geopark is to share the vision of our area with local residents, government officers and academics.Geopark activities are to protect and prevent local resources through local sustainable development.The basic philosophy should be easy to understand and to agree for local residents.

Its philosophy was made by The Council of Unzen Volcanic Area Geopark in 2010 led by local Geopark stakeholders.But, Geopark Programme became the official programme of UNESCO in 2015 andits programme was necessary to contribute and pursue the UNESCO philosophy.

The Council of Unzen Volcanic Area Geopark formulated the new basic philosophy of Unzen Volcanic Area UNESCO Global Geopark in November in 2018 with local residents and government officers to contribute to achieve the philosophy of UNESCO Global Geopark.This is the process how our geopark made the philosophy and showed it to public.

2. The way to consider a new basic philosophy and the flow of workshop with government officers.

I started the project team, which was consisted of Unzen Vlocaninc Area UNESCO Global Geopark members and government officers such as the Ministry of the Environmentry, Nagasaki Prefecture, 3 cities of Shimabara Peninsula (Shimabara, Unzen and Minamishimabara).The project meeting was held 4 times titled "how we build Shimabara Peninsula in the future", and we share each idea by Affinity diagram with the team and group similar ideas which were shared.

As a result, the new basic philosophy was made: "Sustain our beautiful home town and local geo-heritages more and forever".

3. The new basic philosophy sent to local residents

Approximately 230 wide range of local residents including high school students joined the " Japan Geopark authorization 10th anniversary commemoration symposium of Shimabara Peninsula " and have a dialogue to review last 10 year geopark activities and about our future of Shimabara Peninsula.The opinion from participants of the symposium and from project team had in common.The new basic philosophy,as a result, became the one which reflected from local residents' opinions.The new basic philosophy was announced to local residents as declaration of the symposium at the venue.

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4. Our outlook to achieve the new basic philosophy.

It is a task how we pursue the philosophy.for that, we would like to enlarge the number of our fellows towork with us to protect and prevent local resources through local sustainable development.

Keywords: UNESCO, New basic idea, Sustainable development, Affinity diagram, Project team, Local resident

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Evaluation of explanation panels settling at geopark's sites –case study of the explanation panel at a memorial park of houses destroyed by debris flows in Unzen Volcanic Area UNESCO Global Geopark, Japan

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Introduction

Explanation panels placed at Geopark sites are advertising tools to inform local residents and tourists about the value of these sites. These panels enable people to understand how important the sites. However, if the panels only have information that isn't well known to many people, such as geology or geography, they might not be able to understand them smoothly. In order to have people with little knowledge on geology or geography know the values of those sites and have them enjoy the Geopark, it is necessary that the explanation panels are easy to read and understand. In this study, we investigated visitors' impressions on one of the panel at the Geopark's sites. Then, considering the results, we redesigned the contents of the panel and compared the visitor's impressions on it with the original one.

Methods

On August 10th and September 16th in 2018, we placed video camera at *a memorial park of houses destroyed by debris flows*, which is one of the main sites of Unzen Volcanic Area UNESCO Global Geopark, to see how much time visitors look at the explanation panel. We also looked into the visitors' gender, age, hometown, and impressions on the panel. The impressions are evaluated from 1 to 6 points on five different perspectives: total impression, pictures, contents the number of letters, and font size. As for pictures and contents, 6 points is the highest score while 1 point is the lowest. As for the number of letters and font size, 3.5 points is standard and as it gets closer to 1, it means too small or too few pictures, while as it gets closer to 6, it means too big or too many pictures. Then, based on the results, we redesigned the panel and had the same investigation on October 14th and compared the results from both studies.

Results

The number of visitors who saw the original panel was 52 out of a total of 250 visitors (about 21%). The average time they looked at the panel was 22.4 seconds. On the other hand, the number of visitors who saw the redesigned panel was 34 out of 204 visitors (about 17%). The points on impressions were as follows:

1) The original panel: total impression 4.7 / contents 4.6 / pictures 4.6 / the number of letters 4.1 / font size 3.7

2) The redesigned panel: total impression 4.6 / contents 4.8 / pictures 4.7 / the number of letters 4.0 / font size 4.0

The average time the visitors looked at the original panel was about 22 seconds and the longest one was about 63 seconds, while the average and longest times of redesigned panel were 17 seconds and 62 seconds, respectively.

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Discussion

As for the font size, visitors had impressions such as “these are too many letters” or “it is difficult to decide where to start reading” on the original panel. Therefore, we decreased the number of letters and made the font larger on the redesigned one. As a result, the number of people who think the panel became easier to understand has increased. Though the evaluation of the contents improved, the reading time of the redesigned panel became shorter than that of the original one. This implies that visitors were able to finish reading it in a shorter amount of time. On the other hand, some visitors had negative impressions on the redesigned panel such as “there’s not enough information” or “it doesn’t tell information that it should.” This may be because we decreased the number of letters too much and couldn’t show the importance or the values of the sites enough.

Future prospects

Considering the results, we are going to investigate the visitors’ needs for the panel again and redesign it with necessary information to tell the values of the site. We will be able to show you the redesigned one and the visitors’ impressions on it at the conference.

Keywords: Unzen Volcanic Area UNESCO Global Geopark, Geopark, A memorial park of houses destroyed by debris flows, Explanation panels, Evaluation

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ESD-SDGs Promotion Model Development utilizing Geoparks including the basic research on the contents of educational programs in Geoparks in Japan

Katsuhiko Asahi[1], Yayoi Ichihasi[1], Takahiko Ogawara[1], Shinobu Katano[1], Ken'ichi Kurihara[1], *Suzuka Koriyama[1], Takeo Kobayashi[1], kei Shimomura[1], Yusuke Suzuki[1], Ko Takenouchi[1], Tsuyoshi Hibino[1], Jun Fujishima[1], Kana Furusawa[1], Yu Horiuchi[1], Emiko Mizuno[1], Ko Miyama[1], Yuta Yamaoka[1], Tamami Yamaguchi[1], Yukiko Yamasaki[1], Ryuta Yamamoto[1], Hikaru Yokoyama[1]

1. Japanese Geoparks Network

The Japanese Geoparks Network(JGN) started a project aiming at developing a sustainable society through the debelopment and dissemination of Geopark ESD-SDGs practical model.
This project is funded by FP2018 the UNESCO activities grant of the Japanede National Commission for UNESCO. We conducted a survey of educational contents of all the Geoparks in Japan and made the foundation for utilizing these contents widely. We also conducted a survey for educational trip needs to promote edubational trips to Geoparks.
Furthermore,we started to debelop the following five Geopark ESD practical models.

1) UNESCO school Geopark ESD model
2) Elementary and middle school Geopark ESD model
3) High school Geopark ESD model
4) Museum Geopark ESD model
5) International Geopark ESD model

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[J] Poster | O (Public)：Public

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_3

[O-08] How to make the image of the earth's phenomenon to the general people in the Geopark

convener:Noritaka Matsubara(Graduate School of Regional Resource Management, University of Hyogo), Yayoi ICHIHASHI(Sado Island Geopark Promotion Office), Hokuto Obara(Mine-Akiyoshidai Karst Plateau Geopark Promotion Council), Marekazu OHNO(Unzen Volcanic Area Geopark Promotion Office)

unesco global geoparks give international recognition for sites that promote the importance and significance of protecting the Earth's geodiversity through actively engaging with the local communities. in order for the general people to understand the earth's activity, it is necessary to imagine the phenomenon of the earth. in this session, we discuss about how to make the image of the earth's phenomenon to the general people in the Geopark.

[O08-P01] An analysis of the implementation of Mikasa Geopark`s experienced-based GeoTour and its impacts on recruitment and changes in the participant population.

*kei SHIMOMURA[1,2], souta KAMIGUCHI[1,2] (1.Mikasa Geopark Promotion council, 2.Regional Development and Geopark Promotion Division, Mikasa City Office)

[O08-P02] Strategy for revaluation and promotion of Toya-Usu UNESCO Global Geopark through SDGs

*Nire Kagaya[1] (1.Toya-Usu UNESCO Global Geopark Council)

[O08-P03] Examination of the way to convey geo diversity of Mt. Apoi Geopark - Through efforts of geo tour outside the geopark area -

*KATO SATOMI[1] (1.samani town office)

[O08-P04] Geosite Cleanup Activities Leading to Solutions for Global Environmental Problems

*Satoshi Ishikawa[1], Takuya Koike[1] (1.Shimokita geopark promotion council)

[O08-P05] Inspiring geosites and not-inspiring geosites: Case study of the Oga Peninsula-Ogata Geopark

*Norihito Kawamura[1] (1.Faculty of Education and Human Studies, Akita University)

[O08-P06] Are habitats such as fumaroles or areas with heavy snowfall suitable for organisms living in Yuzawa Geopark?
Considering the efficacy of the Geopark Guides with a focus on Yamatanukiran and snow camellia.

*Haruki Takayanagi[1] (1.Yuzawa Geopark Promotion Council)

[O08-P07] **The evaluation of geosites in Sanriku Geopark**

*Sho Nagata[1], Hideo Takagi[2] (1.Waseda University, 2.Department of Earth Science, Faculty of Education and Integrated Arts and Sciences, Waseda University)

[O08-P08] **The nature experience program created by Geopark and National Youth Outdoor Learning Center**

*Takuya Harada[1], Mizuki Kobayashi[1], Ken-ichi Yamada[2], Akiyoshi Adachi[2] (1.Mt. Kurikoma Area Geopark Promotion Committee, 2.National Hanayama Youth Outdoor Learning Center)

[O08-P09] A review of geosites in the Bandaisan Geopark

*Yojiro Taketani[1], Hiroshi Sato[2], Makoto Hasuoka[1] (1.Bandaisan Geopark Council, 2.Mt. Bandai Museum)

[O08-P10] Receiving a Yellow Card: Efforts and Future Actions of Sado Island Geopark

*Yayoi ICHIHASHI[1] (1.Sado Islanad Geopark Promotion Office)

[O08-P11] Method for resetting geosites and their use in Sado Island Geopark

*Takeyoshi SADAKANE[1], Yayoi ICHIHASHI[1], Mituhisa AIDA[1] (1.Sado Island Geopark Promotion Office)

[O08-P12] Look back on the 10 years at the statistical data of the Itoigawa UNESCO Global Geopark

*Takahiko Ogawara[1], Ko Takenouchi[1], Yousuke Ibaraki[1], Takeo Kobayashi[2] (1.Fossa Magna Museum, 2.Itoigawa Geopark Promotion Office)

[O08-P13] Application of terrain representation in Geosite
- Case study in North Ibaraki Geopark Project -

*Go Ishikawa[1], Keiko SUZUKI[1], Mamoru Koarai[2], Rika Imaizumi[3], Naoki Takeda[4] (1.Tokyo Map Research Inc., 2.College of Science, Ibaraki University, 3.Aero Asahi Corp., 4.Association for Promotion of North Ibaraki Geopark Project)

[O08-P14] Evaluation and utilization of 34 geosites in Geopark Chichibu

*Hideo Takagi[1], Satomi Hirose[2] (1.Department of Earth Science, Faculty of Education and Integrated Arts and Sciences, Waseda University, 2.School of Education, Waseda University)

[O08-P16] Aiming for Further Development in Hakone Geopark

Ichiro Murayama[1], Shinobu Katano[1], *Yusuke Okutsu[1] (1.Hakone Geopark Promotion Council)

[O08-P17] Citizen Science Forecast and Evaluate Ship and Airplane Operation Success to a Remote Oceanic Island: a case study for Izu-oshima

Kazuhiro Nakamura[2], Juri Hashimoto[1], *Rika Usui[1], Yuichiro Teramoto[1], Kana Nishitani[3] (1.Izu Oshima Geopark Promotion Committee, 2.Former Tokyo Metropolitan Oshima High School Teacher, 3.Corp. Global Sport Club)

[O08-P18] Minami-Alps Geopark Development of programs for education and spread activities

*Eri Ozawa[1], Takahiro Kitahara[1], Airi Karasawa[1] (1.Minami-Alps MTL area Geopark Council)

[O08-P19] Present situation and issues of the Tateyama Kurobe Geoparkafter Yellow card

*Yuta Yamaoka[1], Akira Takeuchi[1], Hajime Iida[2], Kiyoshi Imai[1], Kazuo Kaneko[1], Yukimitsu Shimura[1], Osamu Inamura[3], Tohru Ikurumi[4], Kiichi Imahori[1], Satoshi Kotani[1] (1.Tateyama Kurobe Geopark Society, 2.Tateyama Caldera Sabo Museum, 3.Uozu Aquarium, 4.Lifelong Learning Division, The Board of Education, Kurobe City)

[O08-P20] 1 year survey conducted by Hakusan Tedorigawa Geopark regarding number of pamphlets taken from Roadside station Shirayamasan

*Nakano Kaori[1], Tsuyoshi Hibino[1], Ryoichi Onishi[1] (1.Hakusan Tedorigawa Geopark Promotion Council)

[O08-P21] Promotion of the earth science utilizing the Geopark “Making the stone specimen in Hakusan Tedorigawa Japanese Geopark”

*Yuya Kitoh[1], Satoshi Hirai[1], Kiyofumi Tamamura[1], Tsuyoshi Hibino[2], Kaori Nakano[2], Tomoaki Morishita[3], Yoshihiro Hiramatsu[3], Maki Hamada[3] (1.Ishikawa Geological Survey Association, 2.Hakusan Tedorigawa Geopark Promotion Council, 3.Kanazawa University)

[O08-P22] School Trip from Hong Kong to Dinosaur Valley Fukui Katsuyama Geopark : Challenges and Prospects

*Sumiaki Machi[1] (1.Dinosaur Valley Fukui Katsuyama Geopark Promotion Council)

[O08-P23] Outline of the activities of the Kumano Kodo Ohechi Rangers

*Keishi Jimbo[1] (1.Nanki Kumano Geopark Guide Club)

[O08-P24] Diversity of Nature Activities Related Geodiversity

maeda atsushi[2], Ministry of the Environment Kinki Regional Environment Office, *Suzuka Koriyama[1], Noritaka Matsubara[3] (1.Sanin Kaigan Geopark Promotion Council, 2.SGAR, 3.Graduate School of Regional Resource Management, University of Hyogo)

[O08-P25] Understanding of regional scientific importance by local Residents – In case of San'in Kaigan UNESCO Global Geopark

*Noritaka Matsubara[1] (1.Graduate School of Regional Resource Management, University of Hyogo)

[O08-P26] Stones forming tombs of feudal lords during Edo period in some geoparks located along the coast of the Sea of Japan

*Tohru Sakiyama[1] (1.Graduate School of Regional Resource Management, University of Hyogo)

[O08-P27] Science Design to make the earth attractive

*Miho Sasaoka[1], Mine-Akiyoshidai Geopark[2] (1.Kochi University / SASAMI-GEO-SCIENCE, Inc., 2.Mine-Akiyoshidai Karst Plateau Geopark)

[O08-P28] 'Be one with the earth; help each other': the Geopark activities of Mine-Akiyoshidai Karst Plateau Geopark

*Hokuto Obara[1], Tomoko Muratani[1], Tristan Gray[1], Kazuhiro Yuhora[2], Koji Wakita[3] (1.Mine-Akiyoshidai Karst Plateau Geopark Promotion Council, 2.Tottori University of Environmental Studies, 3.Yamaguchi University)

[O08-P29] Highlights of Suzaki Coast, Shikoku Seiyo Geopark - Kurosegawa Tectonic Zone, geologic strata of 400 million years ago -

*Chisato Nakamura[1], Tomohiro Tsuji[2], Shikoku Seiyo Geopark Promotion Council [3] (1.NAIBA Co. Ltd., 2.Shikoku Research Institute INC., 3.Seiyo City)

[O08-P30] The Efforts of the Shikoku Seiyo Geopark after the revalidation from JGN council and the 2018 Japan Floods.

*Takumi Sakakiyama[1], Fumito Doi[1], Koshiro Utsunomiya[1], Tsukasa Takahashi[1] (1.Shikoku Seiyo Geopark Promotion Council)

[O08-P31] Method of enjoying relationships with the earth and culture in "the central Shikoku island".

*Azusa Tonotani[1,2], Kana Nakao[1,2], Kazuyoshi Ishii[2], Takuma Asa[3], Soichiro Sagawa[3], Kenshi Nishinari[3], Iori Yamamoto[3], Hisashi Hirao[3], Keiji Nakagawa[3] (1.Miyoshi city office, 2.Geoguides of Miyoshi city, 3.Tokushima prefectural Ikeda high school)

[O08-P32] Bridge of scientific research to school education in a geopark, using a research fund of Muroto UNESCO Geopark

*Takeyuki Ueki[1] (1.Faculty of Risk and Crisis Management, Chiba Institute of Science)

[O08-P33] New basic philosophy of Unzen Volcanic Area UNESCO Global Geopark made in union with local residents and government officers.

*Taku MORIMOTO[1], Marekazu OHNO[1] (1.Unzen Volcanic Area Geopark Promotion Office)

[O08-P34] Evaluation of explanation panels settling at geopark's sites – case study of the explanation panel at a memorial park of houses destroyed by debris flows in Unzen Volcanic Area UNESCO Global Geopark, Japan

Sean OTA[1], Shion MORIKITA[1], Kuumu ONIDUKA[1], Tatsuya MORITA[1], Kenshin OSHIMA[1], Yui KURITA[1], Miyu KAWAZOE[1], Toshiki HIGASHIUCHI[2], Hiroaki OSAKO[2], *Marekazu OHNO[3] (1.Glocal Course, Nagasaki Prefecture Koka High School, 2.Nagasaki Prefecture Koka High School, 3.Unzen Volcanic Area Geopark Promotion Office)

[O08-P35] ESD-SDGs Promotion Model Development utilizing Geoparks including the basic research on the contents of educational programs in Geoparks in Japan

Katsuhiko Asahi[1], Yayoi Ichihasi[1], Takahiko Ogawara[1], Shinobu Katano[1], Ken'ichi Kurihara[1], *Suzuka Koriyama[1], Takeo Kobayashi[1], kei Shimomura[1], Yusuke Suzuki[1], Ko Takenouchi[1], Tsuyoshi Hibino[1], Jun Fujishima[1], Kana Furusawa[1], Yu Horiuchi[1], Emiko Mizuno[1], Ko Miyama[1], Yuta Yamaoka[1], Tamami Yamaguchi[1], Yukiko Yamasaki[1], Ryuta Yamamoto[1], Hikaru Yokoyama[1] (1.Japanese Geoparks Network)

An analysis of the implementation of Mikasa Geopark`s experienced-based GeoTour and its impacts on recruitment and changes in the participant population.

*kei SHIMOMURA[1,2], souta KAMIGUCHI[1,2]

1. Mikasa Geopark Promotion council, 2. Regional Development and Geopark Promotion Division, Mikasa City Office

Mikasa Geopark, located in the center of Hokkaido, joined the Japanese Geopark Network (JGN) in 2013.

Since joining JGN, Mikasa Geopark has focused its efforts on carrying out various experience-based GeoTours.

In recent years, the number of kindergarten and pre-k participants has risen sharply. Mikasa Geopark is successfully achieving its goal of merging geology, and people in a way that appeals to all ages.

The information about GeoTours that appears in this announcement was attained via surveys filled out by participants. The information and the survey results gathered during GeoTour show annual changes across a variety of areas such as participant ages and the number of repeat visitors. Based on these results, we will be conducting further analyses to determine how to improve GeoTours in a way that utilizes of regional history, topography, and the needs of the Geopark as a whole. Going forward, we will be investigating regional opportunities for self-promotion and new activities at the Geopark.

Keywords: GeoTour, Regional Development , MikasaGeopark, GeoHeritage

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Strategy for revaluation and promotion of Toya-Usu UNESCO Global Geopark through SDGs

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1. Toya-Usu UNESCO Global Geopark Council

Toya-Usu UNESCO Global Geopark is located in the southwestern part of Hokkaido. The whole area of Date City, Toyoura Town, Sobetsu Town and Toyako Town is included in the geopark area. In the area, we have the following program which corresponds to SDGs (Sustainable Development Goals). In "Goal 4: Quality education", promotion of ESD (education for sustainable development) is promoted, and "Goal 11: Sustainable cities and communities" includes reductions of victims in natural disasters, regional comprehensive Disaster risk reduction is included.
The disaster prevention leader "Volcano Meister" qualified in the area has lectures of not only the guided tour of the field study to observe the craters and the disaster remains but also the eruption disaster and the life in the shelter. They also offer courses to learn volcanic activities and disasters using outdoor learning textbooks, hazard maps (volcanic disaster prevention maps), equipment that understands volcanic eruptions. In addition to this, we are implementing initiatives related to the achievement of several SDGs. Regarding these efforts, we will further enhance the contents so that more people can use it.
Geopark is a place where you can enjoy various attractions related to the activities of the earth. At the same time, it is a place where you can think about a sustainable society through concrete examples such as natural disasters. Toya-Usu UNESCO Global Geopark is an area where the practice of reducing disaster education has been continued aiming at co-existence with active volcano which continues eruptions. As a UNESCO World Geopark, we will continue to enhance regional education and to promote information dissemination for domestic and overseas as well as improve tourist and trainee acceptance. In this presentation, we will introduce specific measures for that.

Keywords: Geopark, Disaster Risk Reduction Education, SDGs, ESD

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Examination of the way to convey geo diversity of Mt. Apoi Geopark - Through efforts of geo tour outside the geopark area -

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Examination of the way to convey geo diversity of Mt. Apoi Geopark - Through efforts of geo tour outside the geopark area -

Keywords: plate tectonics, geopark, Mt. Apoi, geotourism, geodiversity, Hidaka mountain

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Geosite Cleanup Activities Leading to Solutions for Global Environmental Problems

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1. Shimokita geopark promotion council

The Shimokita area is surrounded by three seas: the Tsugaru Strait, the Pacific Ocean, and Mutsu Bay. The differing characteristics of these seas bring both grace and harm to the area. Various fish are caught in these seas due to differences in the geological features of their sea floors as well as their ocean currents: the Tsushima Current, which flows northward in the Sea of Japan, and the Oyashio Current, which flows southward in the Pacific Ocean. These currents also cause a variety of items to be washed ashore. Once, strange items found washed up along the beach lead to the creation of indigenous religions. Now however, the large amount of sea garbage that collects here is part of a global problem to be solved. People in Shimokita work on global environmental problems through local activities. Local citizens clean the beaches regularly, and some hosted an exhibition of art made from garbage to raise awareness about the problem of marine debris. The Shimokita Geopark Promotion Council also holds advertising campaigns and collaborative events to increase local interest and participation. These activities have increased awareness of both global environmental problems as well as one of the Sustainable Development Goals (SDG), ” Life Below Water.” The promotion of Shimokita Geopark's theme, “Living with Oceans on the Axe-shaped Land,” by the activities of local citizens has inspired other Geoparks to address marine environmental problems and work toward solving them.

Keywords: Shimokita geopark, cleanup activity, global environmental problem

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Inspiring geosites and not-inspiring geosites: Case study of the Oga Peninsula-Ogata Geopark

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The speaker analyzed protocols spoken by the trainee for the Geopark guide in Oga Peninsula –Ogata Geopark. In the question and answer sessions during the training program, response types shown by the trainees are classified into two types; getting knowledge type and no response type. At the geosites showing only something, e.g. fossils, the trainees would ask about something. Hence, the learners show almost nothing at the geosites requiring some cognition to understand. Finally, the speaker insists that geopark guides should choice better instructional method, depending on the visitors' readiness regarding geoscience concepts.

Keywords: geocognition, geopark guide

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Are habitats such as fumaroles or areas with heavy snowfall suitable for organisms living in Yuzawa Geopark? Considering the efficacy of the Geopark Guides with a focus on Yamatanukiran and snow camellia.

*Haruki Takayanagi[1]

1. Yuzawa Geopark Promotion Council

Outline
The biodiversity of Yuzawa Geopark is derived from its unique geodiversity, which includes abundant geothermal activity and heavy snowfall. For example, almost no organisms can persist in the vicinity of the Kawaragejigoku-fumarole, which is a geoformation formed by geothermal activity, snow, and rain water, due to the effect of hydrogen sulfide gas. One exception is the dominant and rare species Yamatanukiran (*Carex angustisquama*). The heavy snowfall in the geopark affects the distribution of snow camellia (*Camellia rusticana*), which has supple branches than can withstand heavy snows. In general, Yamatanukiran and snow camellia are found in acidic soils, such as those located near fumaroles (Tsujimura 1982), or along the land of the Japan Sea side (Sakai 1977). The distributions of these two species reflect key characteristics of this unique region.
Typically, two primary reasons are cited for the observed distributions of these two species: 1) that these species merely prefer these environments and/or 2) that their growth is adapted only to this environment. However, we suspect that such explanations are flawed and/or lack a solid foundation. At first glance, the growth of the two species appears to be adequate at their current locations. Neither species requires the existence of fumaroles or heavy snow, given that Yamatanukiran thrives in agricultural soils (Yuzawa Municipal Sukawa Junior High School, 2011) and that snow camellia is bred at botanical gardens on the Pacific side of Japan (e.g., Koishikawa Botanical Garden, 2019). Yuzawa Municipal Sukawa Junior High School (2011) suggested that the growth rate of Yamatanukiran improves as pH approaches neutrality, and as the distance between individual plants and fumaroles increases. In other words, the influence of soil acidification near fumaroles does not promote the growth of Yamatanukiran but instead inhibits it. Therefore, the fumarole has an overall negative effect on the success of Yamatanukiran. Regarding snow camellia, this species almost certainly experiences damage from avalanches or heavy snow. Based on the above information, we concluded that the restricted distributions of these two species represent their response to strong negative effects rather than being a consequence of fumarole and heavy snowfall environments.
Clearly, in the geopark, as-yet-unknown factors have relegated the two species to inadequate environments.
We refer to plausible reproductive interference [interspecific interactions between closely related species (Takakura and Nishida 2018), e.g., *C. angustisquama* with the widely distributed species, *Carex podogyna* (Fujiwara1997); and *C. rusticana* with a species found along the land of Pacific side of Japan, *Camellia japonica* (Sakai1977)] as the primary factor limiting the biodistribution of the two species, as well as to problems with the academic credibility of the Geopark Guides.

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Keywords: reproductive interference, biogeography, interspecific interactions

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The evaluation of geosites in Sanriku Geopark

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The Sanriku Geopark is the largest national geopark in Japan and involves geodiversity and also remains of repeated Tsunami disasters. It was established in 2013 after the big Tsunami disaster in March 2011. Its geopark status was extended after the review in 2017, however, the result was "yellow card" (next requalification within 2 years), therefore the next review will be scheduled in 2019. The purpose of this study is to evaluate geosites selected from the perspective of various values, highlight their advantages and issues to be considered, and finally contribute to the management of the Sanriku Geopark through presenting this study. In order to attain this purpose, research has been conducted for 65 geosites from 48 areas (previous geosites). They are assessed from the perspective of six main values; educational value, scientific value, tourism value, safety and accessibility, conservation and site sustainability, and value of tourism information (Suzuki and Takagi, 2017). After showing advantage and issues to be considered for each geosites, this study lists up various problems to be considered and presents ways to make the Sanriku Geopark more attractive for many tourists.
Reference: Suzuki, D. A. and Takagi, H., 2017, Geoheritage, 10, 123-135.

Keywords: geosite, evaluation, geopark, Sanriku Geopark

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The nature experience program created by Geopark and National Youth Outdoor Learning Center

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The program called “*Children’s Environment Exploration Corps*” gets to experience nature and aims to promote environmental education. Currently, under the cooperation Mt. Kurikoma Area Geopark and Sanriku Geopark, we are developing content that aims at various ways of enjoying nature and their understanding. In this report, we will introduce the contents and outcomes of 4 activities held since 2017.

In the Sanriku edition, we learned the features and difference of nature and culture of the sea and the land through on-site inspection and experience activities.

In the Mt. Kurikoma Area edition, we learned about various nature and culture spreading on the Mt. Kurikoma Area Geopark through various experience activities.

With the involvement of geoparks, we were able to incorporate new perspectives such as knowledge of nature science and connection with nature and life in activity. Also, children who participated in this program learned new perspectives on nature and how to enjoy them, leading to deepening their interest in nature.

Keywords: geopark, environmental education

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A review of geosites in the Bandaisan Geopark

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1. Bandaisan Geopark Council, 2. Mt. Bandai Museum

It has been 7 years since the Bandaisan Geopark was designated as Japan Geopark. We are currently reviewing whether existing geosites in the area are appropriate for the geopark and trying to discover new geosites with geo-guides. Based on the results, we plan to add and remove the public geosites, to progress sustainable conservation of important geosites and to develop geo-tours with new themes.
The geosites of the Bandaisan Geopark have been selected based on the main theme of the geopark, "To deepen understanding of the birth and transition of the Bandai Volcano, in particular, the large-scale changes in the landform and natural environment due to collapses of the mountain body and debris avalanches and to learn about the influence of Mt. Bandai on people's lives and history and formation of the unique culture".
The Oshio area of Kitashiobara-mura in the northwestern part of the Bandaisan Geopark is mainly composed of the Miocene Green Tuff in the Neogene Period and has important outcrops for understanding the geological history of the period. But, because the geology is not directly related to the formation or eruptive activity of the Bandai Volcano, the area has been excluded from geosites and geo-tours in the geopark.
However, studying the geological history of the Neogene Formation, which forms the basis of the Quaternary volcanoes, provides an important opportunity to understand the plate movements, from the birth of Japan Sea through the uplift of the earth to the formation of Quaternary volcanoes. In addition, there is the Oshio hot spring in the Oshio area, which is visited by many tourists. Salt purified from the hot spring water was an important local resource supplied to the Aizu clan in the Edo period and is even now sold as "mountain salt". The "mountain salt" originates in the seawater of the Green Tuff era, and the role which the heritage of the earth achieved in the history and industry of the region can be shown through a geo-tour. For these reasons, the establishment of new geosites in the Oshio area can be attractive and significant for the geopark.
We will attempt a tour around the newly selected geosites in the Oshio area as the "Geology Day Tour" in 2019 and examine the effects and significance of the tour. Based on the results, we hope to provide a geo-tour with the story for visitors.

Keywords: Bandaisan Geopark, geosite, Oshio hot spring

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Receiving a Yellow Card: Efforts and Future Actions of Sado Island Geopark

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1. Sado Islanad Geopark Promotion Office

In Autumn 2017, Sado Island Geopark was re-examined by JGC and received a yellow card, requiring necessary action to be taken within a two-year period to qualify as a geopark.
I will state the changes in efforts currently underway and initiatives which Sado Island Geopark envisages to take in the near future.

Keywords: geopark, yellow card, sado island

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Method for resetting geosites and their use in Sado Island Geopark

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1. Sado Island Geopark Promotion Office

In recent years, in geoparks in Japan, a definite policy for the classification and definition of sites has been announced by the Japan Geopark Committee.In Sado Island Geopark, all the places of interest have so far been identified with the term ‘geo point’. On this point, in the evaluation report of Sado Island Geopark of 2017, it was pointed out that it is necessary to reclassify all 237 geo points into the geological sites, natural (ecological) sites and cultural sites, as advocated by the UNESCO Global Geoparks.
Based on this recommendation, we created a ‘comprehensive geosite setting plan’ which contains all criteria and procedures such as how to reclassify the geo points into geosites. We are now working on resetting the 237 geo points as geosites.

Two criteria were established in this above-mentioned plan in order to reset geo points as geosites.
The first criterion is for selecting geosites with geoscientific value from geo points, which include sites which also have natural (ecological) and cultural value besides geological value.
The second criterion is whether selected geosites are suitable for actual utilization. Regarding this actual utilization, we established three categories which are ‘for research’, ‘for learning’ and ‘for general purposes (tourism)’ to classify geosites.
Among the selected geosites, those that fit into all three categories will be introduced on our website and in the brochure, and will also be used for sightseeing.

In this presentation, we will describe the geosite resetting method in Sado Island Geopark, introduce the geosites finally chosen, and discuss the utilization of geosites and the challenges that arise from resetting them.

Keywords: Sado Island, geopark, geotourism, geosite, geological heritage

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Look back on the 10 years at the statistical data of the Itoigawa UNESCO Global Geopark

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1. Fossa Magna Museum, 2. Itoigawa Geopark Promotion Office

Itoigawa was designated a Global Geopark in August 2009 and continues activities as the Itoigawa UNESCO Global Geopark today. This paper is a retrospective of the past 10 years of the Itoigawa Geopark, through analysis of statistical data related to tourist sites and geopark activities.

Itoigawa City first implemented the “Fossa Magna and Regional Development Plan” in 1987 to make use of the region’s geological and topographical heritage for tourist promotion. Itoigawa City’s tourism averaged about 3 million visitors per year between 1997 and 2001, but began a downward trend starting in 2002, decreasing further following the Chuetsu Earthquake (2004) and Chuetsu Oki Earthquake (2007) to only 1.85 million visitors in 2007 (Fig 1). Itoigawa was then recognized as a Japanese Geopark in 2008 and a Global Geopark in 2009, which saw a stop in tourism decline. Coinciding with the opening of the Hokuriku Shinkansen, Itoigawa saw 2.49 million visitors in 2015.

The Fossa Magna Museum is Itoigawa Geopark’s central facility. On its opening year in 1994, the museum saw 95,705 visitors, but this had over halved to 40,683 visitors in 2007 (Fig 2). This can be seen to be a result of not only disasters, but also because the museum’s exhibits had never been updated. Following Geopark certification, the museum saw an increase to nearly 60,000 annual visitors and, following the opening of the Hokuriku Shinkansen and a complete renovation of the museum’s exhibits, the museum saw a record-breaking 101,725 visitors in 2015.

Takanami-no-ike Pond is part of the tourism course which visits the Kotakigawa Jade Gorge, one of Itoigawa’s jade producing gorges and Itoigawa’s representative geosite. After Global Geopark certification in 2009, an increase in bus tours saw a peak of 28,940 visitors in 2012. However, bus tours continue to decrease, with only 17,720 visitors in 2014. There is no regular public transportation to Takanami-no-Ike Pond, so the opening of the Hokuriku Shinkansen had no effect on these numbers, and 2017 saw a continued downward trend with only 14,610 visitors.

Itoigawa Geopark formed the Geopark Tourist Guide Society in 2010. During this first year, the guides led 97 tours of 1770 people. The Hokuriku Shinkansen has increased demand for tours and following the Itoigawa City Station North Fire of 2016, tours of the affected areas are also in demand. In 2017, there were 147 tours of 3,645 people recorded.

The Itoigawa Geopark Certification Exam started in 2009 as a ‘gotochi kentei’ regional certification exam. Such exams are popular in Japan to promote study of local culture and history. The first year, which coincided with Global Geopark Certification, saw 464 testees (Fig 3). Itoigawa Geopark and Hong Kong Geopark share a sister geopark relationship and since 2011 have conducted student exchange programs. Itoigawa Geopark requires that participants pass the first level of Itoigawa Geopark Certifications. For this reason, the number of primary school students taking the test increased from 20 in the first year to 86 in 2011.

Recently, foreign tourism to Japan has been increasing dramatically, and Itoigawa is no exception. 2013

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saw only 154 foreign visitors staying in Itoigawa hotels (Fig 4), but since Geoparks became an official UNESCO Program (2015) and the through promotional efforts including the Itoigawa Seafood Shuttle Bus (2015), these have increased to 2,662 visitors in 2017, an increase even more dramatic than that of nearby cities such as Hakuba.
The Geopark Activities have seen an increase in visitors to the Fossa Magna Museum and foreign visitors, but regions of the Geopark that lack public transportation infrastructure like Takanami-no-Ike Pond continue to see a noteworthy decrease in yearly visitors. Furthermore, projects such as the Hokuriku Shinkansen and Geopark Certification Exam have significant effects, but these effects diminish over time. Further polishing of the region’ s attractiveness and development of new programs and activities are essential.

Keywords: Itoigawa UNESCO Global Geopark, Fossa Magna Museum, Kotakigawa Jade Gorge, Sustainable Development

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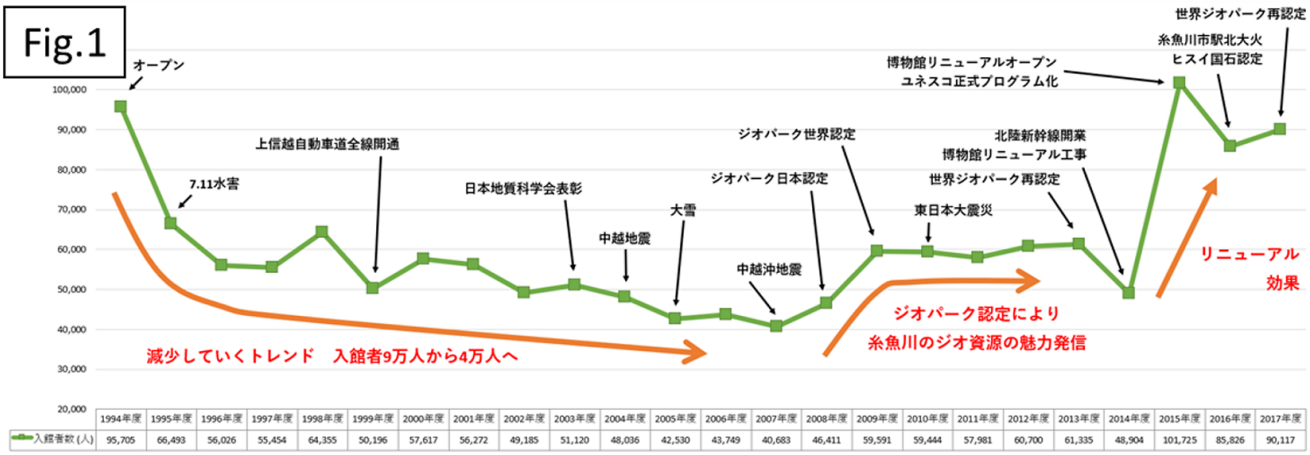
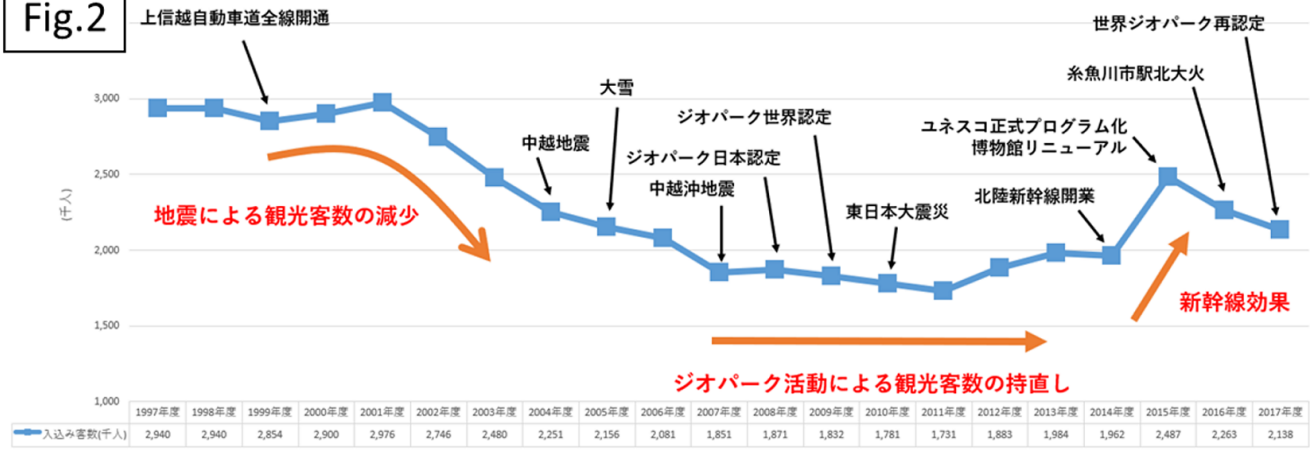
Fig.1



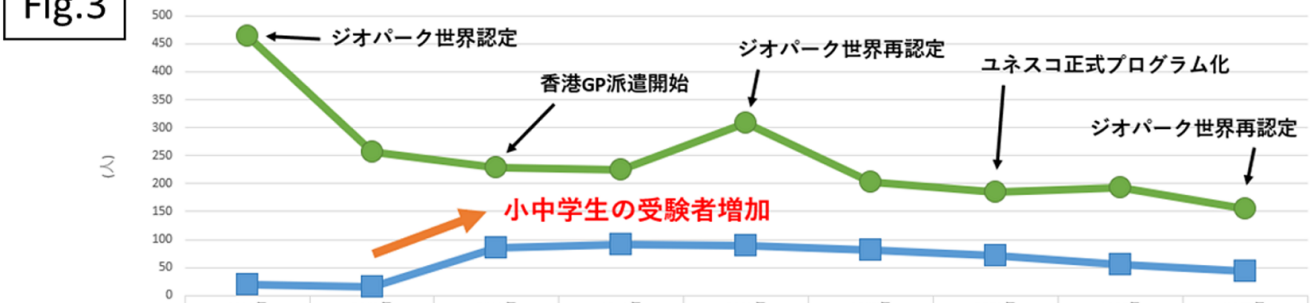
	1994年度	1995年度	1996年度	1997年度	1998年度	1999年度	2000年度	2001年度	2002年度	2003年度	2004年度	2005年度	2006年度	2007年度	2008年度	2009年度	2010年度	2011年度	2012年度	2013年度	2014年度	2015年度	2016年度	2017年度
入館者数(人)	95,705	66,493	56,026	55,454	64,355	50,196	57,617	56,272	49,185	51,120	48,036	42,530	43,749	40,683	46,411	59,591	59,444	57,981	60,700	61,335	48,904	101,725	85,826	90,117

Fig.2



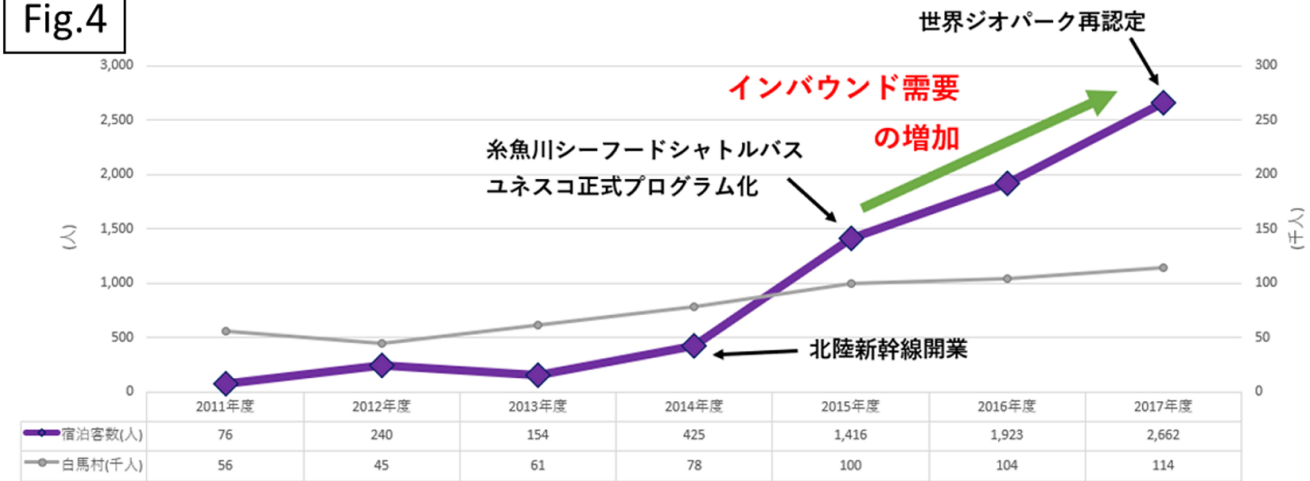
	1997年度	1998年度	1999年度	2000年度	2001年度	2002年度	2003年度	2004年度	2005年度	2006年度	2007年度	2008年度	2009年度	2010年度	2011年度	2012年度	2013年度	2014年度	2015年度	2016年度	2017年度
入込み客数(千人)	2,940	2,940	2,854	2,900	2,976	2,746	2,480	2,251	2,156	2,081	1,851	1,871	1,832	1,781	1,731	1,883	1,984	1,962	2,487	2,263	2,138

Fig.3



	2009年	2010年	2011年	2012年	2013年	2014年	2015年	2016年	2017年
合計受験者数(人)	464	257	229	225	308	202	184	193	155
小中学生受験者数(人)	20	16	86	92	90	81	72	55	43

Fig.4



	2011年度	2012年度	2013年度	2014年度	2015年度	2016年度	2017年度
宿泊客数(人)	76	240	154	425	1,416	1,923	2,662
白馬村(千人)	56	45	61	78	100	104	114

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Application of terrain representation in Geosite - Case study in North Ibaraki Geopark Project -

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Geosites feature the sights of the geopark, which designate sites of spectacular geological feature. It is important to make it have corrected geological information and easily to understand. Most geopark use flyers, but only a few have topographic map.
In the Japanese Geoparks re-certification activity, North Ibaraki Geopark Project has the Geosite pamphlet with map illustration. It's customized and approachable but hard to match with the on-site. To design the new pamphlet, we used **New Relief Map created with Multiple Light Source (DecoBocoChizu Premium)** based on the 5m DEM (Digital Elevation Model). The new Geosite maps show more reality and much easier to recognize the geological feature such as marine terrace, river terrace and fault. Furthermore, overlapping the shadow graph and geologic graph can get the geographic structures.

*: This research is supported by Ibaraki University Geological Information Utilizing Project and KAKENHI (16K01213).

Keywords: Relief Map created with Multiple Light Source, North Ibaraki Geopark Project, terrain representation

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Evaluation and utilization of 34 geosites in Geopark Chichibu

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The Geopark Chichibu was established in 2011 as a national geopark of Japan, and its geopark status was extended after the review in 2015. Next review is scheduled to be conducted in 2019. Geopark Chichibu is claimed to be the birthplace of modern Japanese geology due to its geodiversity since the Meiji era. The purpose of this study is to evaluate 34 new geosites (Inoue and Tomita, 2018) of the Geopark Chichibu from the perspective of various values, highlight their advantages and issues to be considered, and finally contribute to the management of the Geopark Chichibu through presenting this study. In order to attain the above purpose, research has been conducted for 34 (this number is important because of the 34 pilgrimage sites (temples) in Chichibu) new geosites proposed in July, 2018, and additional 5 possible geosites. Total 39 geosite candidates are assessed from the perspective of six main values; educational value, scientific value, tourism value, safety and accessibility, conservation and site sustainability, and value of tourism information (Suzuki and Takagi, 2017). After showing advantage and issues to be considered for each geosites, this study proposes a partial change of new geosite from the perspective of geotourism as well as ways to make the Geopark Chichibu more attractive for many tourists.
References:
Inoue, M. and Tomita, T., 2018, *Bull. Saitama Mus. Nat. Hist.* No. 12, 41-48.
Suzuki, D. A. and Takagi, H., 2017, *Geoheritage*, 10, 123-135.

Keywords: Geopark Chichibu, evaluation of geosites, geotourism

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Aiming for Further Development in Hakone Geopark

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1. Hakone Geopark Promotion Council

Hakone Geopark consists of 2 cities and 3 towns, Hakone Town, Odawara City, Manazuru Town, Yugawara Town and Minamiashigara City, were at first, consisted by 1 city and 3 towns and were authorized by Japanese Geoparks in 2012. After the authorization, there was an increasing momentum to join us in Minamiashigara City, and in 2015, MInamiashigara City, Minamiashigara-Geoguide Association and other related company joined the council. With this new material, we passed the new authorized examination in 2016.

Due to this addition, 8 new geosites were added. For example, at Mt. Yaguratake, a very new rock formation in the world, you can experience the dynamic earth movements of the Ashigara group, which joined the mainland by the collision between the plates. Also Ashigara road which has a history that is older than Tokaido has been added.
Theme of the Hakone Geopark can be understood by studying the geosites. it produced further depth and expanse in Hakone Geopark’ s theme and story.

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Citizen Science Forecast and Evaluate Ship and Airplane Operation Success to a Remote Oceanic Island: a case study for Izu-oshima

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1. Izu Oshima Geopark Promotion Committee, 2. Former Tokyo Metropolitan Oshima High School Teacher, 3. Corp. Global Sport Club

Weather outlook and forecast of ship and airplane operation are invaluable information for daily life in remote islands, but also for tourism and business on those islands. In order to help a local island community, a web site was opened in 2004 to provide an outlook for week-term ship and airplane operation between Tokyo and Izu-oshima and annual report evaluating outlook success ratio for better understandings of nature and climate of Izu-oshima. In collaboration with Izu-shima Geopark, we analyze and discuss a long-term outlook success from 2004 to 2018 for promoting and implementing geo- and eco- tour operation in good, convenient and comfortable seasons of the year.

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Minami-Alps Geopark Development of programs for education and spread activities

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1. Minami-Alps MTL area Geopark Council

In order to know and enjoy the Geopark more deeply, it is effective to listen to the story of the guide by actually looking at the site. However, I think that people who do not know Geopark suddenly participate in geotour etc. are high hurdles.
So, at the Minami-Alps Geopark, we developed a program that allows you to feel free to participate as a catalyst for getting to know the Geopark. And we have been using it in workshop at community center and events. We are also discussing prior learning of educational tour intended for elementary school students' and utilization as rainy day program.
In this presentation, we introduce the mainly about newly developed program and the situation of the use.

Keywords: Geopark, Education

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Present situation and issues of the Tateyama Kurobe Geopark after Yellow card

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1. Tateyama Kurobe Geopark Society, 2. Tateyama Caldera Sabo Museum, 3. Uozu Aquarium, 4. Lifelong Learning Division, The Board of Education, Kurobe City

Tateyama Kurobe Geopark is a Japanese Geopark composed of 9 municipalities in eastern Toyama prefecture and a part of Toyama bay. The features of our Geopark are 4000 meters difference in elevation from the top of Tateyama mountain range with 3000 meters above sea level to the Toyama Bay with depth 1000 meters. Our Geopark was proposed by mainly researchers. The management organization was established by local businesspersons and supported by local governments. Therefore, it is a unique Geopark in Japan that is operated by NGO. Tateyama Kurobe Geopark is operated in cooperation with municipalities, universities and museums. In recent years, more local people, companies and private groups are active about Geopark. The role of Geopark in the region is gradually increasing. However, the result of the Japanese Geoparks revalidation process in 2018 was Yellow card (conditions attached). The main indications are four points as follows (1) difference in recognition about Geopark among participant in Geopark activities, (2) conservation plan and conservation activities are unclear, (3) lack of visibility in major tourist routes and few Geopark signs, (4) difficult explanation. We make and fulfill an improvement plan getting advices from the Japanese Geopark Committee. In this paper, we report activities and issues of the Tateyama Kurobe Geopark considering the results of the revalidation process.

Keywords: Tateyama Kurobe Geopark, Geopark, Conservation, Tourism, Education

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1 year survey conducted by Hakusan Tedorigawa Geopark regarding number of pamphlets taken from Roadside station Shirayamasan

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1. Hakusan Tedorigawa Geopark Promotion Council

Tourism is one of the very important initiatives being focused on by the geopark. Tourism at its core can be thought of as many people visiting a certain area. Also pamphlets exist as a tool able to increase the number of visitors. In recent years the principal means of sharing information has become electronic devices, however conveying information through printed mediums is still effective.
At the Hakusan Tedorigawa Geopark Promotion Council, in order to understand which size and design of pamphlet will catch the customer’ s eye, in January 2018 we started monitoring the number of national geopark regional pamphlets being taken from the roadside station Shirayamasan. When we make future pamphlets this information should allow us to create a pamphlet which both entices customers to take the pamphlet home as well convey the charms of the region.
The roadside station Shirayamasan is located alongside Japan National Route 157, connecting the flatland with the Mt. Hakusan foothills. This roadside station is the entrance gate to the route leading from Ishikawa Prefecture, through the foothills of Mt. Hakusan and onto Fukui and Gifu Prefectures. There is no public transportation such as trains or buses assigned to this route and the roadside station does not currently offer popular services such as restaurants and souvenir shops. Due to this the vast majority of users come by car or bicycle with their main purpose being a brief rest. However, we do not have any information regarding the age, gender, occupation, social status or reason for taking the pamphlets home.
As a result of the monitoring, there was no particular connection found between the number of pamphlets taken last month and the design of the pamphlets or their positioning within the roadside station. However what we did notice was that the season strongly influences the number of people who take pamphlets home. The period over GW (Golden Week –series of national holidays in May), the summer holiday period as well as the popular autumn leaves period saw an increase in the number of pamphlets being taken home. This concludes my report after one year of monitoring the number of pamphlets being taken from the roadside station Shirayamasan.

Keywords: pamphlet, tourism, Hakusan Tedorigawa Geopark, roadside station, public awareness

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Promotion of the earth science utilizing the Geopark “Making the stone specimen in Hakusan Tedorigawa Japanese Geopark”

*Yuya Kitoh[1], Satoshi Hirai[1], Kiyofumi Tamamura[1], Tsuyoshi Hibino[2], Kaori Nakano[2], Tomoaki Morishita[3], Yoshihiro Hiramatsu[3], Maki Hamada[3]

1. Ishikawa Geological Survey Association, 2. Hakusan Tedorigawa Geopark Promotion Council, 3. Kanazawa University

In recent years, due to the declining birthrate, aging of society, and fewer interests of science, new leaders in the field of the natural science has been decreasing. On the other hand, extreme weather with severe damages has increased in recent years. Therefore, it is necessary to develop human resources not only of researchers and engineers with interests of natural science but also of citizens with understanding and knowledge of natural environment.
The Ishikawa Geological Survey Association, the Hakusan Tedorigawa Geopark Promotion Council, and Kanazawa University have organized the event entitled “Making the stone specimen in Hakusan Tedorigawa Japanese Geopark" for elementary school students and their parents since 2017. This event utilizes a field of the Geopark, aiming to make children, as the next generation, have interests in nature and natural science through activities in the field.
On Saturday 20 October 2018, the 35 pairs of children over fourth grade in elementary school and their parents selected by lottery participated joined the event. After learning stones, formation processes of those and how to distinguish them, they collected stones and made the stone specimens with Japanese and foreign students and others using hammers, loupes, and medicinal liquids. From the results of the questionnaire answered by the children after the event, we recognize that the children showed the high curiosity of the stone and the nature, experienced the difficulty and the pleasure of learning the nature. Based on the questionnaire, we verify the learning level of the contents and the explanation of the activity and reflect it in future activities. We are planning to continue this event, as well as trying new attempts to tackle the curiosity of children.

Keywords: New leaders, Geopark, Education, Natural disaster, Field study, Questionnaire

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School Trip from Hong Kong to Dinosaur Valley Fukui Katsuyama Geopark : Challenges and Prospects

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1. Dinosaur Valley Fukui Katsuyama Geopark Promotion Council

Dinosaur Valley Fukui Katsuyama Geopark is located at mountainous region, Fukui Prefecture, Japan. As you can understand from the name of geopark, the region is famous for dinosaur fossils excavation. 5 named dinosaurs have been discovered from Tetori group (early Cretaceous) so far (Azuma & Currie, 2000; Kobayashi & Azuma, 2003; Azuma & Shibata, 2010; Shibata & Azuma, 2015; Azuma et al., 2016). And there are various beautiful landscapes, formed by old volcanic activities and river flows (Kuzuryu rive and its branches).
Fukui Prefectural Dinosaur Museum is very famous in Japan and probably there are many visitors for school trip every year. However, most of them visit there and leave Katsuyama. This has been an old problem of Katsuyama city since the museum was established. We accepted school trip from Hong Kong Chinese Women's Club Fung Yiu King Middle School. We report challenges and prospects about accepting the students trip and guiding them.

Keywords: Dinosauar Valley Fukui Katsuyama Geopark, school trip, Hong Kong UNESCO Global Geopark

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Outline of the activities of the Kumano Kodo Ohechi Rangers

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1. Nanki Kumano Geopark Guide Club

Outline of the activities of the Kumano Kodo Ohechi Rangers

In this poster we will report about the activities of the Kumano Kodo Ohechi Rangers and the relationship between the Nanki Kumano geopark.

The Kumano Kodo Ohechi Rangers was formed in 2004.

The Ohechi route of Kumano Kodo has few flatlands around the coast.

As a result, due to modern traffic improvement many roads of the Ohechi route were duplicated, traces of which were lost.

Volunteers to conduct the exploratory activities of the Ohechi route have gathered, and the Kumano Kodo OhechiRangers is formed.

Search activity is to listen from old people and learn from old maps, investigate the route, rediscover the way.

The exploring activity of the Kumano Kodo Ohechi Rangers revealed about 120 km of the large side route from Tanabe City to Nachikatsura Town, and in 2017 the addition of some part of Ohechito the World Cultural Heritage "Sacred Sites and Pilgrimage Routes in the Kii Mountain Range" was confirmed.

In the vicinity of the Ohechi Route, many of the members of the Kumano Kodo Ohechi Rangers where the major geosites of the Nanki Kumano Geopark are dotted have completed the geopark guide training course and are conducting guide activities.

Also, it is also an area of Yoshino Kumano National Park, and some have registered as a natural park instructor.

Members are actively engaged in the creation of illustration maps, the setting of signposts, the implementation of walking in cooperation with tourism associations and travel agencies, and the conservation activities at local school classes.

I will examine what kind of activities are needed in the future.

Keywords: Geopark, Kumanokodo, maintenance

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Diversity of Nature Activities Related Geodiversity

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1. Sanin Kaigan Geopark Promotion Council, 2. SGAR, 3. Graduate School of Regional Resource Management, University of Hyogo

San’in Kaigan UNESCO Global Geopark is the area stretching from Kyotango City in Kyoto Prefecture; Toyooka City, Kami Town and Shin’onsen Town in Hyogo Prefecture; and Iwami Town and northern part of Tottori City in Tottori Prefecture.

Geopark theme is ‘Geological features, natural environment, people’s lives and the formation of the Sea of Japan.’

There are many organizations which conduct outdoor activities in San’in Kaigan Geopark area. More than 20 bodies in 3 prefectures offer variety of activity programs, making good use of the geological characteristics of the area including the seas (sea kayaking, snorkeling, diving), mountains (mountainous area cycling, treeing), snows (skiing, showshoe), sand dunes (sand board) and rocks (lava trekking).

Each activities need suitable geological features. Diverse activities mean that there are diverse geological features in San’in Kaigan Geopark. In this presentation, I’ll talk about the relationships between variety of activities and the geological features in San’in Kaigan Geopark.

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Understanding of regional scientific importance by local Residents –In case of San’ in Kaigan UNESCO Global Geopark

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Regional self-support is very important things in local community. And one of the important roles of geopark activities is resident understanding of the regional scientific importance and features. UNESCO Global Geoparks give international recognition for sites that promote the importance and significance of protecting the Earth's geodiversity through actively engaging with the local communities. For this purpose, it is important that local residents participate in geopark activities positively. However, it is difficult for local residents to understand regional scientific importance and local geological phenomena.
So, we started “geo-communication” with local people. For example, we created “Geopark foot pass” and “geopark walking map” in cooperation with local people, to promote better understanding and communication with local people, government and academia involved in geopark activities. Local residents could understand geological features through this activity. In this poster, I would like to introduce our “geo-communication” activities.

Keywords: geopark, geo-communication, earth's phenomenon

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Stones forming tombs of feudal lords during Edo period in some geoparks located along the coast of the Sea of Japan

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San’in Kaigan Geopark, Shimane Peninsula and Shinjiko Nakaumi estuary Geopark, and Hagi Geopark are located along the coastal area of Sea of Japan and each has feudal load tombs of the generations. I show the characteristics and speculate the production area of the stones, in the basis of petrography and magnetic susceptibility. Grave site of Ikeda family who are feudal loads of Tottori Domain situate in the San’in Kaigan UNESCO Global Geopark. Most of the tombs in the grave site are made by Mochigase Granite with low magnetic susceptibility located in the south of Tottori City. Stones of tombs in the grave site of Matsudaira family who are feudal loads of Matsu Domain in the Shimane Penninsula and Shinjiko Nakaumi estuary Geopark are clearly divided to older and younger tombs. Former is made of coarse-grained biotite granite with low magnetic susceptibility and latter is made of medium-grained hornblende biotite granodiorite with high magnetic susceptibility. Former ones may be quarried from Seto Inland Sea area and latter ones may be the granite from local area in San’in Zone. Granitic tombs in the Hagi Geopark have also similar tendency.

Keywords: granite, geopark, stone material, magnetic susceptibility

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Science Design to make the earth attractive

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Geoparks goes beyond just the science framework. I think that how geoparks are expected to show relationship earth and people's livelihood of the future and the past in each area.

In order to attract the public, it will be necessary to establish diverse entrances to diverse people.

In this presentation, from the viewpoint of science design, I would like to have the opportunity to think about the future activities of Geopark together, and introducing the completely new efforts I have been doing to the public in general.

Keywords: science design, diverse perspectives

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‘Be one with the earth; help each other’: the Geopark activities of Mine-Akiyoshidai Karst Plateau Geopark

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1. Mine-Akiyoshidai Karst Plateau Geopark Promotion Council, 2. Tottori University of Environmental Studies, 3. Yamaguchi University

In Mine-Akiyoshidai Karst Plateau Geopark, our every activity is conducted under the concept of ‘be one with the earth; help each other’. Through the conservation and utilisation of the earth’s geological heritage, these activities work towards the realisation of the Sustainable Development Goals, which exist for the purpose of achieving UNESCO’s core principle of building peace in the hearts of men and women. This presentation will explain what this concept means in reality, and will introduce the activities already put into practice and plans to be executed in the future in Mine-Akiyoshidai Karst Plateau Geopark, as we look towards achieving UNESCO Global Geopark status.

Keywords: Mine-Akiyoshidai Karst Plateau Geopark, Japanese Geoparks, geopark activity, Sustainable Development Goals

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Highlights of Suzaki Coast, Shikoku Seiyo Geopark - Kurosegawa Tectonic Zone, geologic strata of 400 million years ago -

*Chisato Nakamura[1], Tomohiro Tsuji[2], Shikoku Seiyo Geopark Promotion Council -[3]

1. NAIBA Co. Ltd., 2. Shikoku Research Institute INC., 3. Seiyo City

Kurosegawa tectonic zone is composed mainly of rocks of the continental crust and strata deposited in shallow seas around the continent. It has been assumed that the fragments which has been divided from the supercontinent Pangea near the equator collided with another continent. Suzaki coast is one of the main geological sites of Shikoku Seiyo Geopark in Ehime Prefecture. It is the only location in Japan where the strata of acidic tuff belong to the Kurosegawa tectonic zone crops out continuously for 300 m. The acidic tuff was inclined vertically, creating fantastic landscape. In addition, there are outcrops of tuff breccia and intrusive rocks which are closely related with the acidic tuff. We introduce the highlights of Suzaki coast and explain how these strata were formed.

Acidic tuff: The acidic tuff layer constituted of alternation of muddy and sandy beds. Various sedimentary structures, such as grading, load structure and convolution, those are characteristic in turbidites were formed in the acidic tuff. As showed by Makisaka and Kato (1983), upper direction of the strata faces to the northeast. The acidic tuff includes coarse tephric particles of feldspar, suggesting that it deposited the sea close to continental or volcanic arc. The acidic tuff deposit of 300 m-thick suggests that there was stably volcanic activity over a prolonged period. It is implied that the sedimentary environment of the strata was the sea close to the volcano of the continent. The acidic tuff yields well-preserved radiolarian fossils. Further identification of the radiolarian fossils could contribute to estimate the ages of the sedimentation and the volcanic activity.

Tuff breccia: Tuff breccia including coral fossils overlies unconformably on the acidic tuff with the obvious boundary. The tuff breccia is poorly sorted, and reverse-grading is observed at the bottom of the tuff breccia. Those findings indicate that it is a debris flow deposit formed by the sector collapse or the submarine sliding, and it is presumed that they flowed into the deeper ocean floor.

Intrusive rock: We can see the intrusive rocks at several localities. They cut lamination of the tuff layer and are fine-grained and has massive and homogeneous texture. Since the existence of intrusive rock implies that volcanic activity took place at the site where the acidic tuff deposited, more detailed work is necessary.

On the Suzaki Coast, we can see how the acidic tuff accumulated in the sea close to the continental or the volcanic arc. The Suzaki coast is an academically important place to elucidate the geological history of the Japanese islands and it is also an attractive geological site for the ordinary visitors. Finally, we also introduce how to tour around geological spots in Suzaki coast on the presentation.

Keywords: Shikoku Seiyo Geopark, Kurosegawa tectonic zone, acidic tuff, intrusive rock, debris flow deposit, radiolarian fossil

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The Efforts of the Shikoku Seiyo Geopark after the revalidation from JGN council and the 2018 Japan Floods.

*Takumi Sakakiyama[1], Fumito Doi[1], Koshiro Utsunomiya[1], Tsukasa Takahashi[1]

1. Shikoku Seiyo Geopark Promotion Council

On December 22, 2017, Japanese Geopark Network Council granted the renewal certified status to our Shikoku Seiyo Geopark for another four years. Although we were actively involved in geopark activities after getting the approval of renewal certificate, we had experience of several severe damages due to heavy rain, landslides, and floods in Seiyo City in 2018, and which caused the loss of six people’ s lives. In the Shikoku Seiyo Geopark, the five geosites were damaged among twenty-three sites. The two geosites are still in the state of restricting to the visitors to access for the entry up until now.

In order to respond to the situation, we conducted the educational programs named “Seiyo Nature and Culture College” to the people living around the areas for the awareness of their surroundings. In the programs, we conducted lectures and field trip programs with experts who are familiar with local knowledge and geography, train new courses, and teach the participants how to use the geopark. The participants in the field trips had joyful experience of watching the scenery of the areas familiar from usual as they listened to the commentaries from the experts. In cooperation with school education, we offered the school tours to affected geosites as the annual education program of learning about the geopark.

To improve the indicated matter of revalidation, we are seeking a geopark story that makes visitors interested in the last year. Not only each working committee and geoguides have shared the keywords, but also the participants in the educational programs have taken the discussions. In addition to that, our council have supported the collaborations with local industry and commerce for the preparation for the Shikoku Seiyo Geopark guidebook, establishment of promotion shops, and branding new special products. On the other hand, we also have some challenges of dealing with both disaster response and geopark promotion. For the future, we are going to share the issue in JGN and make the opportunity to learn our lands how it was formed by using new educational material of disaster prevention.

Keywords: Geopark, Seiyo City, revalidation, 2018 Japan floods

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Method of enjoying relationships with the earth and culture in "the central Shikoku island".

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1. Miyoshi city office, 2. Geoguides of Miyoshi city, 3. Tokushima prefectural Ikeda high school

Miyoshi city in Tokushima prefecture is called "the central Shikoku island", which consists of "Sora" and "Machi" area. In the Sora area, villages are scattered on the gentle slopes that are formed by landslides in Shikoku mountains and Sanuki mountain range, and there we can find various creative solutions for living on such landforms in agriculture, architecture and customs. On the other hand, in the Machi area people live on river terraces made by the Yoshino river or on the ground formed by activities of the Median Tectonic Line, where the shredded tabaco industry and water transportation business were prosperous utilizing the Yoshino river.
As stated above, we, Miyoshi city, who has deep relationships with the earth and culture, are promoting activities aiming for the Japanese Geopark certification. We are doing the "Geotours" as one of efforts that have tourists and local people enjoy relationships with the earth and culture.
In this presentation, we introduce four types of the Geotours; by 1) Geologist, 2) Staff in Geopark plan, 3) Geoguide, 4) High school student.

Keywords: Geotour, Median Techtonic Line

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Bridge of scientific research to school education in a geopark, using a research fund of Muroto UNESCO Geopark

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Activities in a geopark is composed of conservation, education and tourism, in ascending order. Scientific research is mainly related to conservation, with little contribution to school education. Drilling survey was performed on the school ground, using a research fund of Muroto UNESCO Geopark. In the field, students observed a drilling work and enjoyed small excursion around. In the laboratory, students cut a sediment core, observed facies and imagined paleoenvironment. This presentation reports a bridge of scientific research to school education in a geopark.

Keywords: bridge, scientific research, school education, research fund, drilling survey

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New basic philosophy of Unzen Volcanic Area UNESCO Global Geopark made in union with local residents and government officers.

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1. Unzen Volcanic Area Geopark Promotion Office

1. Revision of a basic philosophy's of The Council of Unzen Volcanic Area Geopark.

The basic philosophy of Geopark is to share the vision of our area with local residents, government officers and academics.Geopark activities are to protect and prevent local resources through local sustainable development.The basic philosophy should be easy to understand and to agree for local residents.

Its philosophy was made by The Council of Unzen Volcanic Area Geopark in 2010 led by local Geopark stakeholders.But, Geopark Programme became the official programme of UNESCO in 2015 andits programme was necessary to contribute and pursue the UNESCO philosophy.

The Council of Unzen Volcanic Area Geopark formulated the new basic philosophy of Unzen Volcanic Area UNESCO Global Geopark in November in 2018 with local residents and government officers to contribute to achieve the philosophy of UNESCO Global Geopark.This is the process how our geopark made the philosophy and showed it to public.

2. The way to consider a new basic philosophy and the flow of workshop with government officers.

I started the project team, which was consisted of Unzen Vlocaninc Area UNESCO Global Geopark members and government officers such as the Ministry of the Environmentry, Nagasaki Prefecture, 3 cities of Shimabara Peninsula (Shimabara, Unzen and Minamishimabara).The project meeting was held 4 times titled "how we build Shimabara Peninsula in the future", and we share each idea by Affinity diagram with the team and group similar ideas which were shared.

As a result, the new basic philosophy was made: "Sustain our beautiful home town and local geo-heritages more and forever".

3. The new basic philosophy sent to local residents

Approximately 230 wide range of local residents including high school students joined the " Japan Geopark authorization 10th anniversary commemoration symposium of Shimabara Peninsula " and have a dialogue to review last 10 year geopark activities and about our future of Shimabara Peninsula.The opinion from participants of the symposium and from project team had in common.The new basic philosophy,as a result, became the one which reflected from local residents' opinions.The new basic philosophy was announced to local residents as declaration of the symposium at the venue.

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4. Our outlook to achieve the new basic philosophy.

It is a task how we pursue the philosophy.for that, we would like to enlarge the number of our fellows towork with us to protect and prevent local resources through local sustainable development.

Keywords: UNESCO, New basic idea, Sustainable development, Affinity diagram, Project team, Local resident

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Evaluation of explanation panels settling at geopark's sites –case study of the explanation panel at a memorial park of houses destroyed by debris flows in Unzen Volcanic Area UNESCO Global Geopark, Japan

Sean OTA[1], Shion MORIKITA[1], Kuumu ONIDUKA[1], Tatsuya MORITA[1], Kenshin OSHIMA[1], Yui KURITA[1], Miyu KAWAZOE[1], Toshiki HIGASHIUCHI[2], Hiroaki OSAKO[2], *Marekazu OHNO[3]

1. Glocal Course, Nagasaki Prefecture Koka High School, 2. Nagasaki Prefecture Koka High School, 3. Unzen Volcanic Area Geopark Promotion Office

Introduction

Explanation panels placed at Geopark sites are advertising tools to inform local residents and tourists about the value of these sites. These panels enable people to understand how important the sites. However, if the panels only have information that isn't well known to many people, such as geology or geography, they might not be able to understand them smoothly. In order to have people with little knowledge on geology or geography know the values of those sites and have them enjoy the Geopark, it is necessary that the explanation panels are easy to read and understand. In this study, we investigated visitors' impressions on one of the panel at the Geopark's sites. Then, considering the results, we redesigned the contents of the panel and compared the visitor's impressions on it with the original one.

Methods

On August 10th and September 16th in 2018, we placed video camera at *a memorial park of houses destroyed by debris flows*, which is one of the main sites of Unzen Volcanic Area UNESCO Global Geopark, to see how much time visitors look at the explanation panel. We also looked into the visitors' gender, age, hometown, and impressions on the panel. The impressions are evaluated from 1 to 6 points on five different perspectives: total impression, pictures, contents the number of letters, and font size. As for pictures and contents, 6 points is the highest score while 1 point is the lowest. As for the number of letters and font size, 3.5 points is standard and as it gets closer to 1, it means too small or too few pictures, while as it gets closer to 6, it means too big or too many pictures. Then, based on the results, we redesigned the panel and had the same investigation on October 14th and compared the results from both studies.

Results

The number of visitors who saw the original panel was 52 out of a total of 250 visitors (about 21%). The average time they looked at the panel was 22.4 seconds. On the other hand, the number of visitors who saw the redesigned panel was 34 out of 204 visitors (about 17%). The points on impressions were as follows:

1) The original panel: total impression 4.7 / contents 4.6 / pictures 4.6 / the number of letters 4.1 / font size 3.7

2) The redesigned panel: total impression 4.6 / contents 4.8 / pictures 4.7 / the number of letters 4.0 / font size 4.0

The average time the visitors looked at the original panel was about 22 seconds and the longest one was about 63 seconds, while the average and longest times of redesigned panel were 17 seconds and 62 seconds, respectively.

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Discussion

As for the font size, visitors had impressions such as “these are too many letters” or “it is difficult to decide where to start reading” on the original panel. Therefore, we decreased the number of letters and made the font larger on the redesigned one. As a result, the number of people who think the panel became easier to understand has increased. Though the evaluation of the contents improved, the reading time of the redesigned panel became shorter than that of the original one. This implies that visitors were able to finish reading it in a shorter amount of time. On the other hand, some visitors had negative impressions on the redesigned panel such as “there’s not enough information” or “it doesn’t tell information that it should.” This may be because we decreased the number of letters too much and couldn’t show the importance or the values of the sites enough.

Future prospects

Considering the results, we are going to investigate the visitors’ needs for the panel again and redesign it with necessary information to tell the values of the site. We will be able to show you the redesigned one and the visitors’ impressions on it at the conference.

Keywords: Unzen Volcanic Area UNESCO Global Geopark, Geopark, A memorial park of houses destroyed by debris flows, Explanation panels, Evaluation

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ESD-SDGs Promotion Model Development utilizing Geoparks including the basic research on the contents of educational programs in Geoparks in Japan

Katsuhiko Asahi[1], Yayoi Ichihasi[1], Takahiko Ogawara[1], Shinobu Katano[1], Ken'ichi Kurihara[1], *Suzuka Koriyama[1], Takeo Kobayashi[1], kei Shimomura[1], Yusuke Suzuki[1], Ko Takenouchi[1], Tsuyoshi Hibino[1], Jun Fujishima[1], Kana Furusawa[1], Yu Horiuchi[1], Emiko Mizuno[1], Ko Miyama[1], Yuta Yamaoka[1], Tamami Yamaguchi[1], Yukiko Yamasaki[1], Ryuta Yamamoto[1], Hikaru Yokoyama[1]

1. Japanese Geoparks Network

The Japanese Geoparks Network(JGN) started a project aiming at developing a sustainable society through the debelopment and dissemination of Geopark ESD-SDGs practical model.
This project is funded by FP2018 the UNESCO activities grant of the Japanede National Commission for UNESCO. We conducted a survey of educational contents of all the Geoparks in Japan and made the foundation for utilizing these contents widely. We also conducted a survey for educational trip needs to promote edubational trips to Geoparks.
Furthermore,we started to debelop the following five Geopark ESD practical models.

1) UNESCO school Geopark ESD model
2) Elementary and middle school Geopark ESD model
3) High school Geopark ESD model
4) Museum Geopark ESD model
5) International Geopark ESD model

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[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[P-PS04] Mars and Mars system: results from a broad spectrum of Mars studies and aspects for future missions

convener:Hideaki Miyamoto(University of Tokyo), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Ayako Matsuoka(Research Division for Space Plasma, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Sushil K Atreya(University of Michigan Ann Arbor), Chairperson:Sushil Atreya

In view of unprecedented advances in our understanding of Mars, primarily due to new and ongoing observations of the planet with a number of spacecraft missions of the US, Europe and Asia, we propose a session on Mars. Mars is an object of intense scrutiny. Currently, eight spacecraft are operating at Mars, with six in orbit (Odyssey, MRO, MAVEN, Mars Express, Mangalyaan and TGO) and two on the surface (MSL-Curiosity and MER-Opportunity), the largest number ever at any given time. In addition, InSight is on track to land on Mars in November 2018, and several spacecraft are in various stages of implementation with launches scheduled for 2020 (Mars 2020, ExoMars 2020, Emirates Mars Mission Hope, Chinese Mars Mission and the Japanese Mars Terahertz Microsatellite), 2022 (ISRO's Mangalyaan 2), and 2024 (JAXA's MMX mission to explore Phobos, Deimos, and Mars). All this is a clear demonstration of public's strong fascination with and commitment to Mars exploration and the resulting scientific bonanza. Synergistic investigations with ongoing and already completed missions along with modeling studies and earth-based observations are gradually revealing the nature of Earth's most closely resembling planet that took on a different evolutionary track than our home planet. Morphology and variable phenomena seen on the surface (RSLs, e.g.) and in the atmosphere (methane) indicate that Mars is possibly currently active. Available data are providing a better understanding of Mars' present geologic and atmospheric state, climate evolution, and habitability. Thus, the scope of this session will be the recent results from a broad spectrum of Mars studies encompassing the interior, surface, atmosphere, plasma environment, and the Mars system including its two satellites. Abstracts on modelling, instrumentation and future mission plans are also encouraged.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PPS04-01] Recent results from the MAVEN mission

*Dave A Brain[1,4], Bruce Jakosky[1], Janet Luhmann[2], Gina DiBraccio[3] (1.University of Colorado, 2.University of California Berkeley, 3.NASA Goddard Space Flight Center, 4.University of Tokyo)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PPS04-02] From Clouds to Aurora to Atmospheric Escape: Highlights from MAVEN's Imaging UltraViolet Spectrograph

★Invited Papers

*Nicholas McCord Schneider[1], MAVEN/IUVS Science Team (1.LASP, University of Colorado Boulder)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PPS04-03] Variation in Martian Crustal Magnetic Field Cusp Topology

*Tristan David Weber[1], David Brain[1], Shaosui Xu[2], David Mitchell[2], Jasper Halekas[3] (1.University of Colorado, Boulder, 2.Space Sciences Laboratory, UC Berkeley, 3.University of Iowa, Iowa City)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PPS04-04] The Induced Global Looping Magnetic Field on Mars

*Lihui Chai[1], Weixing Wan[1], Yong Wei[1], Tielong Zhang[2], Willi Exner[3], Markus Fraenz[4], Eduard Dubinin[4], Moritz Feyerabend[3], Uwe Motschmann[3], Yingjuan Ma[5], J. S. Halekas[6] (1.Institute of Geology and Geophysics Chinese Academy of Sciences, 2.Space Research Institute, Austrian Academy of Sciences, Graz, Austria, 3.Institute for Theoretical Physics, TU Braunschweig, Braunschweig, Germany, 4.Max Planck Institute for Solar System Research, Goettingen, Germany, 5.Institute of Geophysics and Planetary Physics, University of California, Los Angeles, Los Angeles, CA, USA, 6.Department of Physics and Astronomy, University of Iowa, Iowa City, IA, USA)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PPS04-05] First Observation of Magnetic Pulsations on Martian Surface

*Peter J Chi[1], Christopher T Russell[1], Steve Joy[1], Don Banfield[2], Catherine L Johnson[3,4], Yingjuan Ma[1], Anna Mittelholz[3], Yanan Yu[1] (1.University of California Los Angeles, 2.Cornell University, 3.University of British Columbia, 4.Planetary Science Institute)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PPS04-06] Retrieval of vertical aerosol and gas profiles considering multiple scattering from Martian limb observations by MRO/CRISM

*Yasumasa Kasaba[1], Masashi Toyooka[2], Shohei Aoki[3], Arnaud Mahieux[3,4], Hiromu Nakagawa[2], Hironobu Iwabuchi[2] (1.Planetary Plasma and Atmospheric Research Center (PPARC), Tohoku University, 2.Dep. Geophysics, Tohoku University, 3.Planetary Aeronomy, Belgian Institute for Space Aeronomy, Belgium , 4.University of Texas at Austin, USA)

Recent results from the MAVEN mission

*Dave A Brain[1,4], Bruce Jakosky[1], Janet Luhmann[2], Gina DiBraccio[3]

1. University of Colorado, 2. University of California Berkeley, 3. NASA Goddard Space Flight Center, 4. University of Tokyo

The Mars Atmosphere and Volatile EvolutioN (MAVEN) mission has been making science observations from Mars orbit since November, 2014, with the science goal of assessing the role that loss of atmospheric gas to space has played in changing the Martian climate through time. To achieve this objective, MAVEN measures the energetic inputs to the Martian upper atmosphere from the Sun (“drivers”), the properties of the regions of the upper atmosphere from which escaping particles are drawn (“reservoirs”), and the different escape processes as they occur today (“escape”). These data, and the models used to help understand them, allow us to constrain the influence of escape on the evolution of the Martian atmosphere over time. In this presentation we will summarize the main findings of MAVEN over more than 4 years of science observations, with an emphasis on recent results released over the past year. We will then present the status and future science plans for the mission as the spacecraft’s orbit is changed to prepare for increased relay activities in the coming months and years.

Keywords: Mars, Climate, Atmospheric Escape

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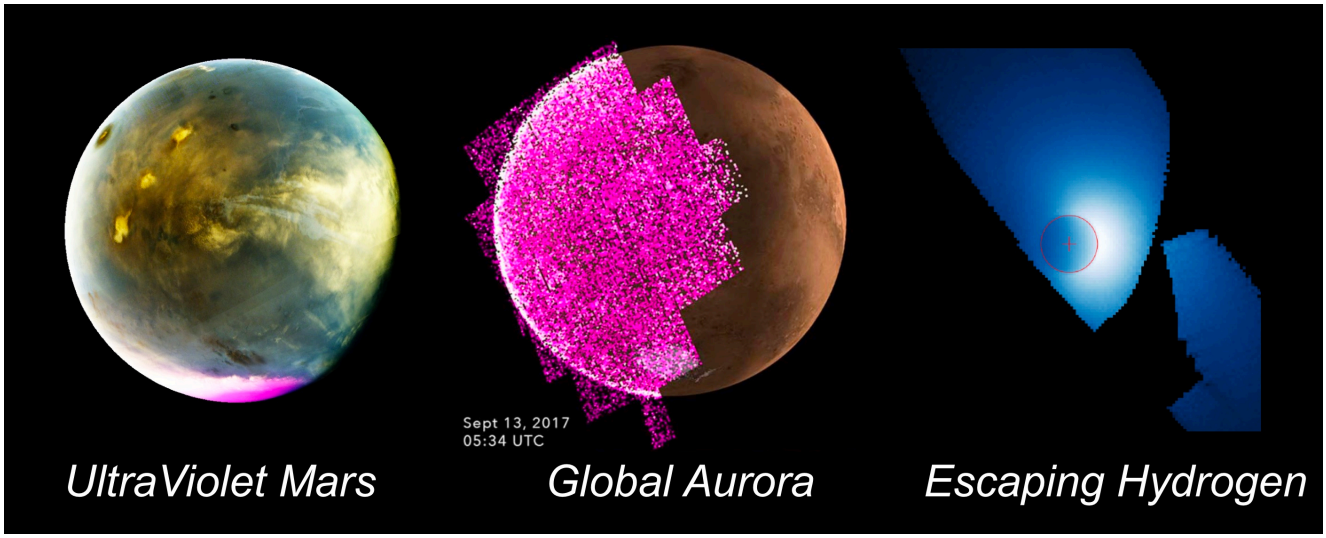
From Clouds to Aurora to Atmospheric Escape: Highlights from MAVEN's Imaging UltraViolet Spectrograph

*Nicholas McCord Schneider[1], MAVEN/IUVS Science Team

1. LASP, University of Colorado Boulder

The Mars Atmosphere and Volatile EvolutioN (MAVEN) mission's Imaging Ultraviolet Spectrograph (IUVS) observes Mars in the far and mid ultraviolet (110-340 nm), investigating lower and upper atmospheric structure and indirectly probing neutral atmospheric escape. The instrument is among the most powerful spectrographs sent to another planet, with several key capabilities: separate Far-UV & Mid-UV channels for stray light control; a high-resolution echelle mode to resolve deuterium and hydrogen emission; internal instrument pointing and scanning capabilities to allow complete mapping and nearly continuous operation; and optimization for airglow studies. After four Earth years in orbit (two Mars years), IUVS has assembled a large quantity of data and provided insights on present-day processes at Mars including dayglow, nightglow, aurora, meteor showers, clouds, and solar-planetary interactions. In this presentation, we will highlight key results obtained by IUVS, including: (1) dust storm and cloud activity from a synoptic perspective; (2) a surprisingly high level of auroral activity of three types; (3) long-term tracking of seasonally-modulated escape of hydrogen. We will present an overview of these results and a discussion of their implications for understanding Mars atmospheric dynamics and evolution.

Keywords: mars, atmosphere, ultraviolet, aurora, escape, clouds



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Variation in Martian Crustal Magnetic Field Cusp Topology

*Tristan David Weber[1], David Brain[1], Shaosui Xu[2], David Mitchell[2], Jasper Halekas[3]

1. University of Colorado, Boulder, 2. Space Sciences Laboratory, UC Berkeley, 3. University of Iowa, Iowa City

The Martian magnetic field environment is complex. Crustal magnetic fields interact with the incoming interplanetary magnetic field (IMF) to produce a dynamic topological system that in turn constrains the motion of charged particles. The inflow of energetic electrons and the outflow of ionospheric particles are both channeled through regions of vertically oriented field referred to as magnetic "cusps". These cusp regions are consequently host to a range of energetic processes including field-aligned currents and aurora, and may be the source of substantial quantities of ion escape at Mars.
Here we present an analysis of variability in crustal cusps, using electron pitch-angle distributions and energy distributions measured by MAVEN to study how cusp topology varies with upstream solar wind conditions. We find that increased solar wind pressure causes an increase in the spread of open cusp regions on both the dayside and nightside of the planet, and that changes in IMF direction control which cusps preferentially open to the solar wind. Finally, we then pair these results with direct measurements of particle flux to begin an analysis of energy deposition and ion outflow in cusp regions.

Keywords: Martian Magnetosphere, Magnetic Topology, Martian Ionosphere

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The Induced Global Looping Magnetic Field on Mars

*Lihui Chai[1], Weixing Wan[1], Yong Wei[1], Tielong Zhang[2], Willi Exner[3], Markus Fraenz[4], Eduard Dubinin[4], Moritz Feyerabend[3], Uwe Motschmann[3], Yingjuan Ma[5], J. S. Halekas[6]

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Magnetic fields inconsistent with draped IMFs and crustal fields have been observed on Mars. Considering the discovery of a global looping magnetic field around the Venusian magnetotail and the similarities in the solar wind interactions between Mars and Venus, we use MAVEN observations to investigate the global looping field on Mars and its formation mechanism. It is found that a global looping field also exists on Mars; therefore, this type of global looping field is a common feature of unmagnetized planetary bodies with ionospheres and it should also exist on Titan and near-Sun comets. The comparison of the looping fields on Mars and Venus shows that the looping field is stronger on Mars. Solar wind azimuthal flows around the magnetotail towards the -E magnetotail polar region (X_MSE<0,Y_MSE=0,Z_MSE}<-1R_M) are observed. We illustrate that the looping field can be formed by bending the draped field lines with these azimuthal flows, and that these azimuthal flows are associated with heavy ion plumes along the +E direction that are expected to be stronger on Mars than Venus. The current system associated with the looping field and its possible connection with the nightside ionosphere formations and ion escapes on Mars and Venus are discussed.

Keywords: Mars, Venus, induced magnetosphere, looping magnetic field

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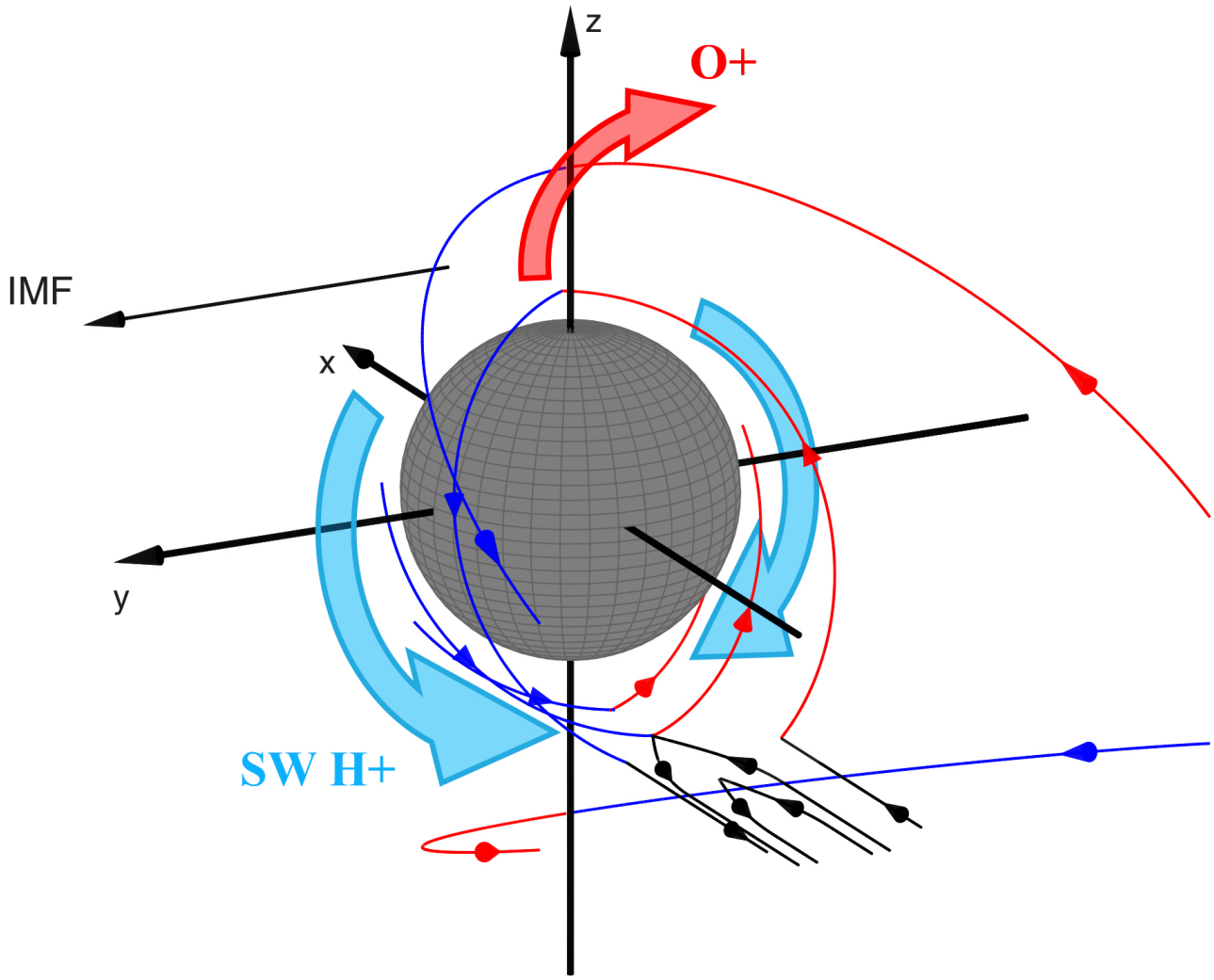

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First Observation of Magnetic Pulsations on Martian Surface

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Landed in the western Elysium Planitia on Mars on November 26, 2018, InSight is the first Mars surface mission that carries a magnetometer. One of the research topics that can be investigated by using the InSight FluxGate (IFG) magnetometer observations is ultra-low-frequency (ULF) magnetic pulsations. Past and ongoing Mars orbiter missions have observed several types of magnetic pulsations near the planet, but whether any of them can reach the Martian surface is an open question. We study the initial IFG data to examine whether and what types of magnetic pulsations are present on the Martian surface. We have found continuous pulsations (Pc) with frequencies at ~10 mHz occurring mostly near midnight. Pc at lower frequencies (of the order of 1 mHz) has also been found in the local morning. The data from the Temperature and Wind for InSight Subsystem (TWINS) confirm that these ULF oscillations in the IFG data are not caused by the wind-driven motion of the lander. Data from the Mars-orbiting MAVEN spacecraft show that the ~10-mHz magnetic pulsations observed by InSight are different from the upstream waves in the foreshock region but may be induced by the oscillations in the tail plasma sheet. The observed continuous pulsations on the Martian surface near midnight are distinct from what are typically observed on the Earth's surface at the same local hours. The different field and plasma environment at Mars raises interesting questions regarding how the magnetic pulsations in the induced magnetosphere propagate to the surface.

Keywords: Mars, NASA InSight mission, surface magnetic field, induced magnetosphere, solar wind interaction with Mars

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Retrieval of vertical aerosol and gas profiles considering multiple scattering from Martian limb observations by MRO/CRISM

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Mars must somehow have lost most of its atmosphere and water. The evolution of the Mars environment is thought to have proceeded by atmospheric escape to space. In the last decades, there have been a renewed interest from lower to upper atmosphere to understanding the Martian climate. Vertical profiles of atmospheric gases and aerosols are thus the primary information for key processes in energy and mass transport into the upper atmosphere from below. Thanks to the aggressive explorations by MRO and MEx missions, there have been a lot of dataset of limb-viewing observations that can add new restrict the history of the Martian environment. However, these limb datasets haven’t started on the retrieval due to their computational costs in the process of radiative transfer calculations.

JACOSPAR is a fast RT code that considers multiple scattering that simulates the radiance and Jacobians in the fully spherical geometry, which has been developed for the terrestrial atmosphere. We have newly developed the retrieval code by applying JACOSPAR for Martian limb observation. For the first step to apply JACOSPAR to Martian limb observation, we modified two points for RT simulations to be optimized. First, we implemented a uniform distribution of line of sight within the field of view (FOV) in order to reduce the resultant variance of the calculated radiance along line of sight in the FOV. Second, we also optimized the threshold of Russian roulette method for the efficient calculation in the Monte Carlo simulation.

The evaluation results of Jacobians calculated by JACOSPAR showed the agreements accurate within 2% and 10% for absorption and scattering, respectively, in almost cases. In order to evaluate our retrieval code and its proper implementations, we have applied our retrieval code for the MRO/CRISM limb observations. We conducted spectral fitting to retrieve vertical profiles of number density of CO#CO,H#O,dust,andwatericefor the observed spectra by CRISM in the altitude range from 0 to 20 km. Here we newly attempted to retrieve the mean radius, and its variance of aerosols for the two cases of difference a priori conditions for the variance of aerosols’ radius of 0.5 and 1.2. We, however, still found the discrepancy of spectral slope and intensity between retrieved spectra and measured spectra. It is also noted that the repetitive variations of fitting profiles do not converge during the iterations. The possible explanation for the discrepancy of the spectral slope and intensity might be due to the treatments of aerosol properties. One of the solutions is to apply modified-gamma distribution for size distribution function, instead of log-normal distribution function applied for this study.

More precise and accurate treatment of size distribution function is required as a next step. The repetitive variations of fitting profiles might be caused by the sensitivity of the retrieval. The detailed evaluation of the retrieval sensitivity should also be required for the future work.

Keywords: Mars, Retrieval , atmosphere, vertical profile

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[E] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[P-PS04] Mars and Mars system: results from a broad spectrum of Mars studies and aspects for future missions

convener:Hideaki Miyamoto(University of Tokyo), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Ayako Matsuoka(Research Division for Space Plasma, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Sushil K Atreya(University of Michigan Ann Arbor), Chairperson:Hideaki Miyamoto, Tomohiro Usui

In view of unprecedented advances in our understanding of Mars, primarily due to new and ongoing observations of the planet with a number of spacecraft missions of the US, Europe and Asia, we propose a session on Mars. Mars is an object of intense scrutiny. Currently, eight spacecraft are operating at Mars, with six in orbit (Odyssey, MRO, MAVEN, Mars Express, Mangalyaan and TGO) and two on the surface (MSL-Curiosity and MER-Opportunity), the largest number ever at any given time. In addition, InSight is on track to land on Mars in November 2018, and several spacecraft are in various stages of implementation with launches scheduled for 2020 (Mars 2020, ExoMars 2020, Emirates Mars Mission Hope, Chinese Mars Mission and the Japanese Mars Terahertz Microsatellite), 2022 (ISRO's Mangalyaan 2), and 2024 (JAXA's MMX mission to explore Phobos, Deimos, and Mars). All this is a clear demonstration of public's strong fascination with and commitment to Mars exploration and the resulting scientific bonanza. Synergistic investigations with ongoing and already completed missions along with modeling studies and earth-based observations are gradually revealing the nature of Earth's most closely resembling planet that took on a different evolutionary track than our home planet. Morphology and variable phenomena seen on the surface (RSLs, e.g.) and in the atmosphere (methane) indicate that Mars is possibly currently active. Available data are providing a better understanding of Mars' present geologic and atmospheric state, climate evolution, and habitability. Thus, the scope of this session will be the recent results from a broad spectrum of Mars studies encompassing the interior, surface, atmosphere, plasma environment, and the Mars system including its two satellites. Abstracts on modelling, instrumentation and future mission plans are also encouraged.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PPS04-07] **MODELING MORE COMPLEX EARLY MARTIAN ATMOSPHERES AND DETERMINING THE RESULTING PRECIPITATION AND EROSION RATES**

*Ramses M Ramirez[1,2] (1.Earth-life Science Institute, 2.Tokyo Institute of Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PPS04-08] GCM simulations of the present and past water environment on Mars

*Takeshi Kuroda[1,2], Arihiro Kamada[1], Katsushige Toriumi[1], Yasumasa Kasaba[1], Naoki Terada[1], Hiromu Nakagawa[1] (1.Faculty of Science, Tohoku University, 2.National Institute of Information and Communications Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PPS04-09] Cold-based glaciation at Pavonis Mons, Mars: Evidence for moraine deposition during glacial advance

★Invited Papers

*Reid Parsons[1,2], Tomohiro Kanzaki[3], Ryodo Hemmi[1], Hideaki Miyamoto[3] (1.University Museum, University of Tokyo, 2.Earth and Geographic Science Dept., Fitchburg State University, 3.Dept. of Systems Innovation, University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PPS04-10] Possible Earth-like tectonic scenario on Mars; a mineralogical and geochemical perspective

*Trishit Ruj[1], Gene W Schimdt[2], Goro Komatsu[2], Kenji Kawai[1] (1.Department of Earth and Planetary Science, School of Science, UTokyo, Japan, 2.International Research School of Planetary Sciences,

Università d'Annunzio, Italy)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PPS04-11] Hydration state of the Martian lithosphere constrained from gravity and topography

*James Daniel Paul Moore[1], Jon Wade[2], Anthony B Watts[2], Richard M Palin[3], Lars M Hansen[2], Brendan Dyck[4], Jun Muto[6], Andrew J Smye[5], Adam D Switzer[1] (1.Earth Observatory of Singapore, 2.University of Oxford, 3.Colorado School of Mines, 4.Simon Fraser University, 5.Penn State, 6.Tohoku University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PPS04-12] SUBGLACIAL ANTARCTIC LAKE VOSTOK VS. SUBGLACIAL SOUTH POLE MARTIAN LAKE AND HYPERSALINE CANADIAN ARCTIC LAKES – PROSPECTS FOR LIFE

*Sergey Bulat[1] (1.NRC KI - Petersburg Nuclear Physics Institute, Saint-Petersburg-Gatchina, Russia)

MODELING MORE COMPLEX EARLY MARTIAN ATMOSPHERES AND DETERMINING THE RESULTING PRECIPITATION AND EROSION RATES

*Ramses M Ramirez[1,2]

1. Earth-life Science Institute, 2. Tokyo Institute of Technology

The early Mars climate problem remains one of the most interesting ones in planetary science. In particular, the high degree of fluvial surface erosion, as exemplified by modified craters and large winding ancient valley networks, suggests that early Mars may have exhibited a more Earth-like climate in the past. However, climate models have always struggled to simulate the warmer and wetter conditions that were apparently required to explain these observations, given that early Mars (~3.8 Ga) received less than 1/3 the solar insolation that reaches our planet today. One possibility is that warm climate conditions on early Mars were maintained by a multi-bar CO_2-rich atmosphere (with H_2O vapor), mirroring conditions that may have been true during the early days of Earth and Venus. However, climate models have repeatedly shown that a dense CO_2 atmosphere alone is insufficient to generate warm conditions.

This inability of climate models to warm planets using the conventional greenhouse gases (i.e. CO_2 and H_2O) had prompted us and other groups to consider additional warming from secondary absorbers, such as H_2 and CH_4. Both CO_2-H_2 and CO_2-CH_4 atmospheres have been shown to generate above-freezing mean surface temperatures, which are high enough to explain the existence of geological features that were most likely carved by running water.

However, these previous calculations were performed by single-column radiative convective climate models that can only compute mean-averaged planetwide properties and are unable to spatially resolve atmospheric and surface parameters. Such models are also unable to evaluate the effects of oceans on climate, or compute precipitation and the resulting erosion rates to compare with those inferred from observations. On the other end, 3-D models, although quite complex, are very expensive computationally and are unable to explore parameter space as fully and completely as can simpler models. For best results, 3-D models also require a level of knowledge about the planet that, although available for present Earth, is simply unavailable for early Mars, which necessarily results in making many assumptions that cannot be tested or verified as with any other model.

Here, I present my advanced 2-D non-grey energy balance model, which provides a nice compromise between complexity and speed for this problem. It contains 36 latitude bands, clouds, topography, the ice-albedo feedback, and accurate radiative transfer directly computed from detailed single-column climate modeling calculations. Ocean sizes can be varied and planetary parameters, including eccentricity and obliquity can be computed. A typical simulation takes less than a minute. I present some preliminary results (Figure 1).

We will present simulation results for CO_2-H_2 and CO_2-CH_4 atmospheres of various H_2 (0 -20%) and CH_4 (0- 10%) concentrations, pressures (0 –3 bar), while varying ocean size given various literature estimates. From these simulations, we will compute atmospheric and surface temperatures as a function of latitude, yielding precipitation rates, and the resultant erosion rates as a function of latitude. These latitudinal erosion rates will be compared against those inferred for observations. Should such erosion rates be too

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high, we can conclude that the resultant climates are too wet/warm. Likewise, should they be too low, the climates are not wet enough. Thus, for the first time we will be able to constrain realistic atmospheric compositions using a relatively complex model that may satisfy the available atmospheric and geologic constraints, providing a glimpse into what the ancient atmosphere could have actually been like. We will also discuss the implications of our results and give hypotheses that can be tested by upcoming and future missions searching for ancient geology and even life.

Keywords: early Mars, life, climate, atmospheres, erosion

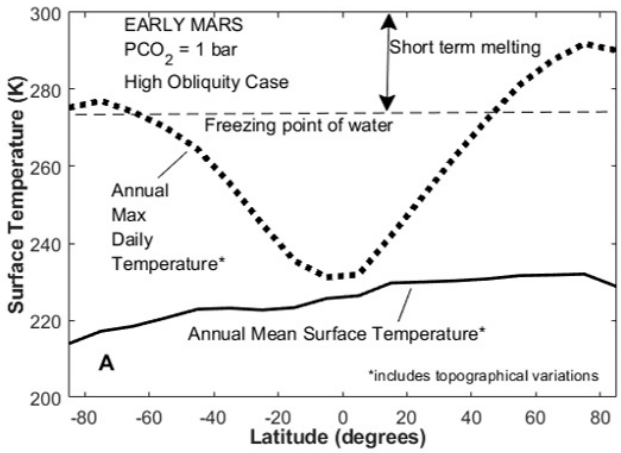

Figure 1: Computed surface temperatures per latitude band, which agrees well with the similar 1-bar case from the 3-D model of Wordsworth et al. 2015 Fig.1.

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GCM simulations of the present and past water environment on Mars

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Though the current Mars is a dry planet, the ancient Mars is thought to have been a water-rich planet like the present Earth. There are many topographic evidences of past liquid water flow, which should be hints for the past climate on Mars. Most of the liquid water is thought to have escaped into space, but even on the present Mars, some water environments have been found as the permanent north polar cap, underground ice, and possibly salty liquid water.

On the present Mars, water vapor exists in the atmosphere with the mixing ratio of up to hundreds of ppmv from surface up to ~100 km altitude, and water ice clouds also exist in low-latitudes around aphelion (northern summer) with the infrared opacity of up to ~0.2 and winter polar regions. The north polar ice sheet is thought to be the main source of atmospheric water, as well as possibly the underground water. Also the detection and mapping of HDO/H2O ratio in the atmospheric water could be hints for the history and movement of water. Our Mars global climate model (MGCM), DRAMATIC, has simulated such water environment consistently with the available observations, and the detailed investigations are ongoing with high-resolution (horizontal resolution of ~67 km) simulations.

Moreover, we have simulated the paleoclimate on Mars using a MGCM for paleoclimate (PMGCM), with a dense CO2 atmosphere with the surface pressure of up to a few bars. Radiative effects of water vapor may contribute the warming, and the existence of liquid ocean and lakes contributes the supply of water in the atmosphere. Our PMGCM simulation with ocean/lakes estimated the distributions of fluvial and sediment discharges from the precipitation and snow accumulations, and showed the agreements with the observed valley networks with several exceptions.

Keywords: Mars, water cycle, water environment, paleoclimate, global climate model

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Cold-based glaciation at Pavonis Mons, Mars: Evidence for moraine deposition during glacial advance

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1. University Museum, University of Tokyo, 2. Earth and Geographic Science Dept., Fitchburg State University, 3. Dept. of Systems Innovation, University of Tokyo

The three large volcanoes in the Tharsis region of Mars: Arsia, Pavonis, and Ascraeus Montes all have fan-shaped deposits (FSDs) on their northern or western flanks consisting of a combination of parallel ridges, knobby/hummocky terrain, and a smooth, viscous flow-like unit. The FSDs are hypothesized to have formed in the Amazonian during a period of high spin-axis obliquity which redistributed polar ice to the equatorial Tharsis region resulting in thick (>2 km), flowing ice deposits.

The ridged units in the FSDs are hypothesized to be deposited during glacial recession based on their similarity to terrestrial analogs in the Dry Valleys of Antarctica [1] and Iceland [2,3]. Crater age dates [4] suggest glacial recession took place slowly over hundreds of millions of years, but that recession episodically halted for a period of about a million years [4] in order to deposit an individual ridge. However, the 120 kyr periodicity in obliquity [5-7] is the most likely climate signal to influence the redistribution of ice and glacial dynamics. Therefore, there is an inconsistency between the million-year timescale attributed to ridge formation and the climate variation timescale. To investigate the process of ridge formation, we conducted numerical simulations of ice accumulation and flow using temperature and mass balance assumptions associated with Amazonian global circulation models [8] and laboratory experiments of ice sublimation under martian conditions [9].

We find that ice flow ceases during glacial retreat due to the reduction in ice thickness associated with the slow sublimation (0.5 mm/yr) of buried ice. Laboratory experiments of sublimation of buried ice supports this model assumption [9] as does the presence of remnant ice deposits within the Pavonis FSD. Because ice flow has ceased during glacial retreat, there is no mechanism to advect surface debris to form a ridge.

The model results, when combined with topography observations of a long sequence of ridges located interior of the Pavonis FSD, show that the ridged units were more likely deposited during one or more periods of glacial advance (instead of retreat) when surface temperature variations caused by 120 kyr periodicity obliquity oscillations propagated through the ice deposit resulting in a fluctuating ice flow rate. A model-derived ice flow rate of 3 cm/yr during glacial advance can deposit an average interior ridge in less than 100 kyrs if the supraglacial debris layer is two or more meters thick.

The pattern in ridge spacing observed at Pavonis Mons is more consistent with ridge deposition occurring during glacial advance. These ridges were overrun by the advancing ice, but remained preserved due to the cold temperatures at the glacier bed. Evidence supporting the preservation of ridges underneath an ice sheet comes from intersecting ridge sequences at Arsia and Pavonis [10], as well as the superposition of remnant ice (the smooth unit) on top of ridges.

Our hypothesis links the dominant, 120 kyr periodicity in obliquity to the time interval between adjacent ridges. By measuring the spacing between these ridges and dividing by the obliquity periodicity, we constrain the velocity of glacial margin to be between 0.2 and 4 cm/Earth yr - in close agreement with the

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numerical simulation. Furthermore, a comparison with a simulation conducted under terrestrial gravity confirms the prediction of steeper ice margins on Mars during glacial advance which may contribute to ridge deposition via mass wasting, although invoking mass wasting is not required by our hypothesis so long as the supraglacial debris layer is >2 m thick. This re-interpretation of the FSD ridged unit suggests that the timescale of FSD formation (and perhaps the duration of the Amazonian high obliquity period) was shorter than previously reported.

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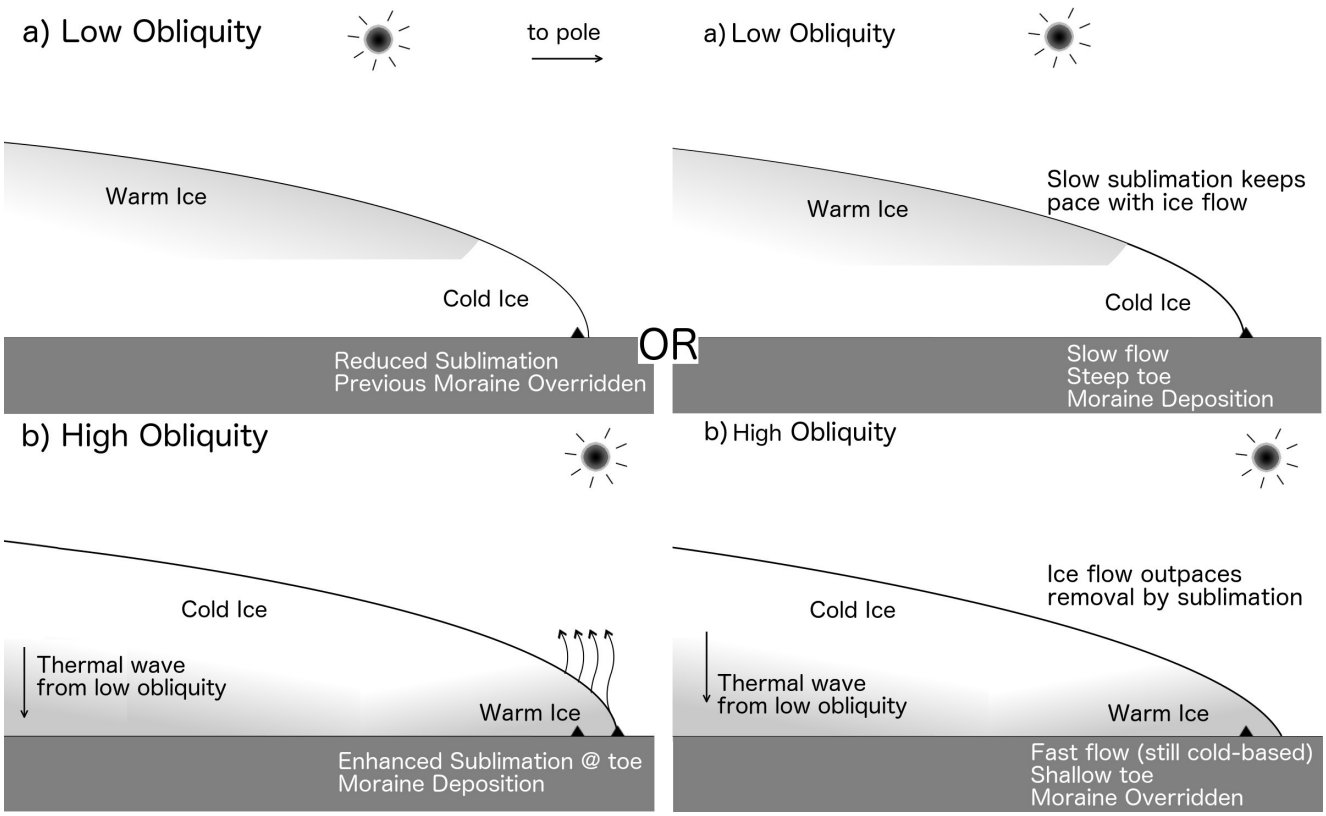
Keywords: Mars, Glaciation, Climate



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Possible Earth-like tectonic scenario on Mars; a mineralogical and geochemical perspective

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The southern highlands of Mars preserve a series of Noachian aged (Eoarchean equivalent to Earth) grabens with multiple orientations and morphologies (Ruj et al., 2018). We have found traces of a 3000 km long succession of grabens (with individual grabens ranging from 30 to 1200 km) in the Noachis Terra and Terra Sabaea region around the western boundary of the massive Hellas basin. However, the origin of these grabens is neither confirmed to be a result of Earth-like plate tectonics or related to giant impacts such as Hellas, Argyre and Isidis. Here, after preparing the geological map, we present our preliminary observation (using remotely sensed datasets) on the mineralogy of the rocks and the geochemistry of the crust associated with the grabens. The hyperspectral analysis of several CRISM (Compact Reconnaissance Imaging Spectrometer, onboard the Mars Reconnaissance Orbiter) observations indicates the presence of olivine, pyroxene (clino), plagioclase, phyllosilicates and hydrated sulfates. GRS (Gamma Ray Spectrometer onboard on Mars Odyssey) observation of the area shows a higher abundance of Potassium (K) and Thorium (Th) than their average global distribution. Plagioclase, olivine and pyroxene are the main constituents of basalts and the GRS derived geochemistry confirms the existence of this alkali basalt type with a higher abundance of Potassium (K). Meanwhile, Thorium (Th) content is higher than the surroundings, indicating the presence of granitic composition rocks which are typically found within continental rift zones on Earth associated with bimodal volcanism.

Keywords: Mars, Tectonics, Martian mineralogy

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Hydration state of the Martian lithosphere constrained from gravity and topography

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Widespread aqueous alteration of the Martian crust suggests that metamorphic hydration reactions may have played a critical role in the sequestration of water early during the planet’s history. The presence of hydrous phases in the Martian crust reduce its bending strength, and we show that observations of the Martian gravity anomaly may be used to constrain the fate of Martian surface water.

Using the gravity anomalies associated with notable topographic features, such Olympus Mons, as well as the global gravity and topography, we construct yield strength envelopes for hydrous and anhydrous end-member crustal sections, and derive the predicted elastic thicknesses, Te, a proxy for the long-term lithospheric strength of Mars. We also use spherical harmonic coefficients that describe the Martian gravity anomaly and topography fields to quantify the role of isostasy in contributing to crustal and upper mantle structure. Power spectra of these fields reveal that the gravity effect of topography and its flexural compensation contributes significantly to the observed free-air gravity anomaly spectra for spherical harmonic degree $8 < n < 50$, corresponding to wavelength $300 < \lambda < 3000$ km. The best-fit global average is for an elastic plate (flexure) model with T_e of ~126 km. All isostatic models under-predict the spectra at $2 < n < 5$, and we interpret the low-order Martian gravity field, at least in part, to be the result of processes that formed the Northern Basin. By comparing the observed Martian T_e to that predicted for our metamorphic mineral assemblages, we iterate on the water content until convergence. In short, we show the bending strength of Mars places constraints on the amount of hydration of the Martian crust, which in turn we use to calculate the planetary water budget. Notably, the stiffer flexural response of Olympus Mons is consistent with its younger age and eruption predominantly into a dry environment.

Keywords: Mars, Flexure, Gravity

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SUBGLACIAL ANTARCTIC LAKE VOSTOK VS. SUBGLACIAL SOUTH POLE MARTIAN LAKE AND HYPERSALINE CANADIAN ARCTIC LAKES –PROSPECTS FOR LIFE

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The objective was to search for microbial life in the subglacial freshwater Antarctic Lake Vostok by analyzing the uppermost water layer entered the borehole following successful lake unsealing at the depth 3769m from the surface. The samples included the drillbit frozen and re-cored borehole-frozen water ice. The study aimed to explore the Earth’ s subglacial Antarctic lake and use the results to prospect the life potential in recently discovered subglacial very likely hypersaline South Pole ice cap Martian lake (liquid water reservoir) [1] as well as similar subglacial hypersaline lakes (reservoirs) in Canadian Arctic [2].

The Lake Vostok is a giant (270 x 70 km, 15800 km2 area), deep (up to 1.3km) freshwater liquid body buried in a graben beneath 4-km thick East Antarctic Ice Sheet with the temperature near ice melting point (around -2.5°C) under 400 bar pressure. It is extremely oligotrophic and poor in major chemical ions contents (comparable with surface snow), under the high dissolved oxygen tension (in the range of 320 –1300 mg/L), with no light and sealed from the surface biota about 15 Ma ago [3].

The water frozen samples studied showed very dilute cell concentrations - from 167 to 38 cells per ml. The 16S rRNA gene sequencing came up with total of 53 bacterial phylotypes. Of them, only three phylotypes passed all contamination criteria. Two phylotypes were reported before [4] - hitherto-unknown and phylogenetically unclassified phylotype w123-10 likely belonging to *Parcubacteria* Candidatus *Adlerbacteria* and 3429v3-4 showing below-genus level (93.5%) similarity with *Herminiimonas glaciei* of *Oxalobacteraceae* (*Beta-Proteobacteria*) –water-inhabited ultramicrobacterium isolated from a deep Greenland ice core. The new third finding (the phylotype 3698v46-27) proved to be conspecific with several species of *Marinilactobacillus* of *Carnobacteriaceae* (*Firmicutes*). All three bacterial phylotypes may represent ingenious microbial communities in the subglacial Lake Vostok.

Two newly discovered (RES) subglacial hypersaline lakes (5 and 8.3km2 areas) in the Canadian Arctic are settled in bedrock throughs beneath 560 and 740m ice cap with modeled temperature below -10.5°C [2] and isolated by a glacier for at least 120 Ky ago. The biology is not yet studied (lakes are not unsealed), but the life potential is rather high (while dissimilar to the Lake Vostok). Their estimated salinity (140-160 psu) is in a range of that observed for brine-rich water body beneath Taylor Glacier (–7.8˚C, 125 psu) and the ice-covered Lake Vida (–13˚C, 200 psu) in Antarctica, both inhabited by active unique microbial communities.

The just discovered (RES) 20km-wide subglacial lake beneath the South Pole ice cap on Mars [1] should be ultra-hypersaline because it is buried beneath a 1.5km water ice cap with modeled temperature -68° C. It is well below known low-temperature limits supporting terrestrial microbial cell propagation and metabolism as well (-18°C and -33°C, respectively [5]). Such conditions may indicate zero-level life potential for this lake from the Earth-bound point of view, but its exploration may give us surprises.

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In general, all three subglacial lakes (complexes) –two Earth-bound and one Martian, may host unique life forms never met before but their exploration (unsealing) is challenging as it happened with the Lake Vostok.

The reported study was partly funded by RFBR according to the research project №18-55-16004.

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Keywords: Antarctica, Subglacial Lake Vostok, Subglacial Mars South Pole ice cap lake, Subglacial hypersaline Canadian lakes, Bacterial 16S rRNA genes, Astrobiology

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SUBGLACIAL ANTARCTIC LAKE VOSTOK VS. SUBGLACIAL SOUTH POLE MARTIAN LAKE AND HYPERSALINE CANADIAN ARCTIC LAKES – PROSPECTS FOR LIFE

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Keywords:
Antarctica, subglacial Lake Vostok, Mars, subglacial South Pole ice cap lake, subglacial hypersaline Canadian lakes, Lake Vostok unsealing, frozen water, life, extremophiles, bacteria, 16S rRNA genes, astrobiology

Introduction:
The objective was to search for microbial life in the subglacial freshwater Antarctic Lake Vostok by analyzing the uppermost water layer entered the borehole following successful lake unsealing at the depth 3769m from the surface. The samples included the drillbit frozen and re-cored borehole-frozen water ice. The study aimed to explore the Earth's subglacial Antarctic lake and use the results to prospect the life potential in recently discovered subglacial very likely hypersaline South Pole ice cap Martian lake (liquid water reservoir) [1] as well as similar subglacial hypersaline lakes (reservoirs) in Canadian Arctic [2].
The Lake Vostok is a giant (270 x 70 km, 15800 km2 area), deep (up to 1.3km) freshwater liquid body buried in a graben beneath 4-km thick East Antarctic Ice Sheet with the temperature near ice melting point (around -2.5°C) under 400 bar pressure. It is extremely oligotrophic and poor in major chemical ions contents (comparable with surface snow), under the high dissolved oxygen tension (in the range of 320 – 1300 mg/L), with no light and sealed from the surface biota about 15 Ma ago [3].
The water frozen samples studied showed very dilute cell concentrations - from 167 to 38 cells per ml. The 16S rRNA gene sequencing came up with total 53 bacterial phylotypes. Of them, only three phylotypes passed all contamination criteria. Two phylotypes were reported before [4] - hitherto-unknown and phylogenetically unclassified phylotype w123-10 likely belonging to *Parcubacteria* Candidatus *Adlerbacteria* and 3429v3-4 showing below-genus level (93.5%) similarity with *Herminiimonas glaciei* of *Oxalobacteraceae* (*Beta-Proteobacteria*) – water-inhabited ultramicrobacterium isolated from a deep Greenland ice core. The new third finding (the phylotype 3698v46-27) proved to be conspecific with several species of *Marinilactobacillus* of *Carnobacteriaceae* (*Firmicutes*). All three bacterial phylotypes may represent ingenious microbial communities in the subglacial Lake Vostok.
Two newly discovered (RES) subglacial hypersaline lakes (5 and 8.3km2 areas) in the Canadian Arctic are settled in bedrock throughs beneath 560 and 740m ice cap with modeled temperature below -10.5°C [2] and isolated by a glacier for at least 120 Ky ago. The biology is not yet studied (lakes are not unsealed), but the life potential is rather high (while dissimilar to the Lake Vostok). Their estimated salinity (140-160 psu) is in a range of that observed for brine-rich water body beneath Taylor Glacier (−7.8°C, 125 psu) and the ice-covered Lake Vida (−13°C, 200 psu) in Antarctica, both inhabited by active unique microbial communities.
The just discovered (RES) 20km-wide subglacial lake beneath the South Pole ice cap on Mars [1] should be ultra-hypersaline because it is buried beneath 1.5km water ice cap with modeled temperature -68°C. It is well below known low-temperature limits supporting terrestrial microbial cell propagation and metabolism as well (-18°C and -33°C, respectively [5]). Such conditions may indicate zero-level life potential for this lake from the Earth-bound point of view, but its exploration may give us surprises.
In general, all three subglacial lakes (complexes) – two Earth-bound and one Martian, may host unique life forms never met before but their exploration (unsealing) is challenging as it happened with the Lake Vostok.
The reported study was partly funded by RFBR research project №18-55-16004.

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[E] Poster | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_3

[P-PS04] Mars and Mars system: results from a broad spectrum of Mars studies and aspects for future missions

convener:Hideaki Miyamoto(University of Tokyo), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Ayako Matsuoka(Research Division for Space Plasma, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Sushil K Atreya(University of Michigan Ann Arbor)

In view of unprecedented advances in our understanding of Mars, primarily due to new and ongoing observations of the planet with a number of spacecraft missions of the US, Europe and Asia, we propose a session on Mars. Mars is an object of intense scrutiny. Currently, eight spacecraft are operating at Mars, with six in orbit (Odyssey, MRO, MAVEN, Mars Express, Mangalyaan and TGO) and two on the surface (MSL-Curiosity and MER-Opportunity), the largest number ever at any given time. In addition, InSight is on track to land on Mars in November 2018, and several spacecraft are in various stages of implementation with launches scheduled for 2020 (Mars 2020, ExoMars 2020, Emirates Mars Mission Hope, Chinese Mars Mission and the Japanese Mars Terahertz Microsatellite), 2022 (ISRO's Mangalyaan 2), and 2024 (JAXA's MMX mission to explore Phobos, Deimos, and Mars). All this is a clear demonstration of public's strong fascination with and commitment to Mars exploration and the resulting scientific bonanza. Synergistic investigations with ongoing and already completed missions along with modeling studies and earth-based observations are gradually revealing the nature of Earth's most closely resembling planet that took on a different evolutionary track than our home planet. Morphology and variable phenomena seen on the surface (RSLs, e.g.) and in the atmosphere (methane) indicate that Mars is possibly currently active. Available data are providing a better understanding of Mars' present geologic and atmospheric state, climate evolution, and habitability. Thus, the scope of this session will be the recent results from a broad spectrum of Mars studies encompassing the interior, surface, atmosphere, plasma environment, and the Mars system including its two satellites. Abstracts on modelling, instrumentation and future mission plans are also encouraged.

[PPS04-P01] Observation of the O_2^+ first negative band (1,0) emissions in the Mars ionosphere with a visible spectrograph on Haleakala T60

*Toshihisa Suzuki[1], Masato Kagitani[1], Takeshi Sakanoi[1] (1.PPARC, Graduate School of Science, Tohoku University)

[PPS04-P02] Search of shallow subsurface reflectors around RSLs in Martian Chryse and Acidalia planitiae by the MRO/SHARAD public data

*Aina Oura[1], Yasumasa Kasaba[1], Atsushi Kumamoto[1], Rina Noguchi[2], Tomohiro Usui[2], Ken Ishiyama[2], Chihiro Uemura[3] (1.Tohoku University, 2.Institute of Space and Astronautical Science, 3.SOKENDAI)

[PPS04-P03] Detecting surface changes on Mars using principle component analysis of repeat imagery

*Reid Parsons[1], Hideaki Miyamoto[1] (1.University of Tokyo)

[PPS04-P04] Evaluation of the detectability of hydrated salts on recurring slope lineae on Mars.

*Shoko Imamura[1,2], Yasuhito Sekine[2], Hiroyuki Kurokawa[2] (1.University of Tokyo, 2.Earth-Life Science Institute, Tokyo Institute of Technology)

[PPS04-P05] Frequency of ice sheet growth recorded on Mons Pavonis, Mars

*Tomohiro Kanzaki[1], Reid Parsons[1,2], Ryodo Hemmi[1], Hideaki Miyamoto[1] (1.University of Tokyo, 2.Fitchburg State University)

[PPS04-P06] Development of Life Detection Microscope (LDM) for *in situ* imaging of living cells on Mars surface

*Yoshitaka Yoshimura[1], Akihiko Yamagishi[2], Takehiko Satoh[3], Atsuo Miyakawa[2], Eiichi Imai[4], Satoshi Sasaki[5], Kensei Kobayashi[6], Yoko Kebukawa[6], Tomoka Okada[6], Keigo Enya[3], Hikaru Yabuta[7], Takeshi Naganuma[7], Hajime Mita[8], Kazuhisa Fujita[3], Tomohiro Usui[3] (1.College of Agriculture, Tamagawa University, 2.Tokyo University of Pharmacy and Life Science, 3.Japan Aerospace Exploration Agency, 4.Nagaoka University of Technology, 5.Tokyo University of Technology, 6.Yokohama National University, 7.Hiroshima University, 8.Fukuoka Institute of Technology)

[PPS04-P07] Development of a Mars Web-GIS for viewing multiple kinds of spectral data from orbiters

*Yuya Matsubara[1], Hironori Fukuchi[1], Yoshiko Ogawa[1], Yohei Hayashi[2] (1.The University of Aizu, 2.National Astronomical Observatory of Japan)

[PPS04-P08] **Visualization and Analysis of the Surface of Mars with NASA's Mars Trek Portal**

*Brian Hamilton Day[1], Emily Law[2] (1.NASA Solar System Exploration Research Virtual Institute, NASA Ames Research Center, 2.NASA Jet Propulsion Laboratory, California Institute of Technology)

[PPS04-P09] Increase in Dissolved Iron Concentration from Fayalite by UltravioletA・C Irradiation

*Nobuo Komori[1] (1.The United Graduate School of Education Tokyo Gakugei University)

[PPS04-P10] Small-scale ridges newly identified on the equatorial region of the Phobos nearside

*Ryodo Hemmi[1], Hiroshi Kikuchi[1], Hideaki Miyamoto[1] (1.The University of Tokyo)

[PPS04-P11] Development of a compact Muography instrument for future Mars exploration missions

*Hiroaki Kamiyoshihara[1], Tetsuro Ninomiya[1], Yuri Yoshihara[1], Kenji Shimazoe[1], Hiroyuki Takahashi[1], Hiroyuki Tanaka[1], Hideaki Miyamoto[1] (1.University of Tokyo)

Observation of the O_2^+ first negative band (1,0) emissions in the Mars ionosphere with a visible spectrograph on Haleakala T60

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We carried out ground-based telescope observations of Martian ionospheric O_2^+ emission to obtain global distribution of Martian O_2^+ ionosphere and its variation for understanding Martian atmospheric escape process. After verifying the analysis method, the result suggests that the O_2^+ first negative bands (1NG) (1, 0) emissions are successfully detected, and calculated O_2^+ emission intensity and column density.
Mars has tenuous atmosphere compared with the Earth. One possible model for Martian tenuous atmosphere is caused by atmospheric escape to space for a long time. In addition, present Mars has only weak crustal magnetic fields for limited area, and therefore, it is likely that solar wind strongly affects Martian atmosphere escape. In recent years, ion composition and densities in the Martian ionosphere are revealed by Mars probes (e.g. Mars Express, MAVEN). In the Martian ionosphere, main ion is O_2^+ [M. Benna et al., 2015]. Moreover O_2^+ recombines with an electron, and as a result of a neutral molecule dissociation, neutral atomic oxygens are generated. Since the neutral atomic oxygen energy is higher than escape velocity of Mars, it can be escaped from Martian gravity. This process is important in Martian atmosphere escape. However, it is difficult to detect atomic oxygen by Mars probe in-situ observation, and escape quantity is indirectly estimated by plasma temperature and density from in-situ observations. On the other hand, remote-sensing of Martian ionosphere is useful to obtain global distribution and its time and spatial variations. It is essential to combine in-situ plasma data with global remote sensing for understanding Martian atmospheric escape, such as solar wind impact and/or crustal magnetic field effect on the escape process.
We carried out Martian ionosphere O_2^+ emission observation using Tohoku University T60 telescope (located at the summit of Mt. Haleakala in Maui) with Vispec (Visual imager and Spectrograph with Coronagraphy) from September 10 to 19, 2018. This is the first attempt to detect Martian O_2^+ emission with a ground-based telescope. We focused O_2^+ 1NG (1, 0) bands emission with a peak wavelength of about 561 nm. Visible Echelle spectrograph Vispec (wavelength resolution was 10,000) covered wavelength range from 550 nm to 570 nm. Vispec slit (width 2” ×length 90”) was located near Martian dayside limb parallel to the Martian rotation axis, and exposure time of one frame was 2 minutes. Total exposure time in observation period was 450 minutes. To refer sunlight spectrum reflecting by Martian surface, we acquired spectrum of disk center by Martian surface. First analysis process (subtraction dark, revision by flat-field, wavelength and space) was conducted on each frame, and each frame was added to gain S/N. Finally, sunlight spectrum was subtracted using disk center to obtain O_2^+ 1NG (1, 0) bands emission spectrum. Next, we compared observed O_2^+ spectrum with O_2^+ 1NG (1, 0) model spectrum given by Henriksen and Veseth [1987]. Focusing on only short period wavelength variations, we performed high-pass filter analysis on the both of observed and model spectrum. After that, we calculated the correlation coefficient between observed spectrum and model spectrum, and found that the coefficient maximum is 0.40 with no wavelength lag between two spectra. Data points, i.e., wavelength range, using correlation coefficient analysis were selected so that model O_2^+ emission is relatively intense and the contamination of solar fraunhofer absorption line is negligible. We estimated O_2^+ 1NG (1, 0) emission intensity with a least-square method to be 691 +/- 171 $\times 10^3$ Rayleighs, and the column density to be 4.4 +/- 1.1 $\times 10^{13}$ /cm^2. The estimated column density was greater than that of simulation. In this presentation, we compare O_2^+ emission observation spectrum with model spectrum, and give the estimation of O_2^+ emission intensity and column density in detail. We also give discussion about the

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results.

Keywords: Mars, ionosphere, ground-based telescope

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Search of shallow subsurface reflectors around RSLs in Martian Chryse and Acidalia planitiae by the MRO/SHARAD public data

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One of recent discoveries on Mars is the recurring slope lineae (RSL), which are certain features on the surface invoking current icy processes. RSLs are distributed on Mars and these narrow features incrementally lengthen down steep slopes, fade in colder seasons, and recur annually. Candidate and confirmed RSL sites are distributed in four regions, (1) southern mid-latitudes (SML), (2) Valles Marineris (VM), (3) equatorial highlands, and (4) northern Chryse Planitia and southwestern Acidalia Planitia (CAP). The RSLs in (2) VM and (4) CAP are more densely located than other two areas.
This study tries to identify the subsurface structures of the northern mid-latitude RSL in (4) Chryse and Acidalia Planitiae by the public data of Mars shallow radar sounder (SHARAD) onboad the Mars Reconnaissance Orbiter opened on the PDS Geosciences Node. That is because CAP RSLs are densely distributed compared to other regions. CAP RSLs are found on the steep slopes of craters. Their source zones are at or below the elevation of the surrounding plains. We used the Java Mission-planning and Analysis for Remote Sensing (JMARS, https://jmars.asu.edu/) in order to investigate the geological information of the RSL sites and the MRO locations at the SHARAD observed data. We then picked up the location correspond to the RSL sites and generated radargrams from SHARAD data. The observation frequency of SHARAD is 15-25 MHz with the bandwidth of 10 MHz, and the subsurface close to the surface can potentially be resolved with the depth resolution of 15 m in vacuum. Using MOLA data, we generated the virtual radargrams with the surface clutter emulated by the Kirchhoff approximation. Then, we compared both observed radargrams with emulated ones to identify whether there are subsurface reflectors or not.
We surveyed about 12 orbits close to the confirmed RSLs. We could find the hypothetical detection of the subsurface reflector in ‘orbit.00688101’ (Jan 14 2008, N10.0-44.7˚, E313.6-318.3˚) and ‘orbit.00673602’ (Jan 03 2008, N10.1-44.7˚, E312.7-317.4˚). In this abstract, we concentrated the characteristics of the former candidate. In this sample, the closest RSL located at N34.1˚, E317.0˚ and nadir line from the orbit was 13.8 km. Another RSL close to this orbit located N34.8˚, E318.6˚ and nadir line from the orbit was 85.2 km. Apparent elevation of closest RSL was about -3,763 ±10 m. The deepest elevation of the crater was about -4,744 ±10 m and the highest elevation of it was about -3,640 ±10 m. The radargram of this orbit showed that the elevation of surface echo was in the range from -3720 to -3780 m and that of subsurface echo ranged from -3750 to -3800 m. This means that the closest RSL height was almost the same as the depth of subsurface reflector. The subsurface echo located 25 m below the surface, and it had a little bit weak echo strength compared to surface one. If this subsurface echo shows the underground reflection, the subsurface layer will be 180 km wide along the orbit. Although this depth is marginal for the depth resolution of SHARAD, we could not identify such an echo in the emulated radargram.
In the presentation, we will summarize the results of this region including other orbits.

Keywords: Mars, RSL, SHARAD

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Detecting surface changes on Mars using principle component analysis of repeat imagery

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Change detection is an analytical tool of Remote Sensing in which repeat observations of a particular location can be overlain, subtracted, or ratioed to detect differences between images. High-resolution, repeat imagery on Mars has led to several discoveries of ongoing geologic processes operating at the sub-kilometer scale such as recurring slope lineae (RSL) [1-3], new, small impacts [4], aeolian dune migration [5], sublimation of polar ice [6], and gully formation [7]. Generally, the detection of these changes is done manually by overlaying, and “flipping” between the two images. As planetary remote sensing data sets continue to grow, so does the need for a more efficient means of change detection.

Principle component analysis (PCA) offers an advantageous means for detecting change because it considers the values of all pixels in all the repeat images to extract the most statistically significant variations. These variations are then isolated from one another as a hierarchical set of “principle components” of the image dataset. The user can quickly identify patterns or features of interest which are present in one or more of these components. To illustrate this method, nine HiRISE images [8] collected from Palikir crater on Mars between November 2007 and June 2011 documenting RSL formation will be used.

PCA changes the values of the pixels in each image by plotting the pixel data on a set of axes which capture the maximum variance in the dataset. In our example image set, each pixel in the image stack can be treated as a 9-dimensional vector since there is a value for that pixel in each of the nine images. However, each pixel can be plotted on a new set of axes that capture the most important, or PCs of the image stack.

The figure shows the result of the PC transform (performed using ENVI® software) on the stacked time-series. Because most of the variation in the images is captured in the first PC (PCA1), it uses a grayscale color bar spanning 0-255 pixel values. Generally, variations covering a large spatial extent or variations causing a big shift in pixel values will be captured in the lower PCA components. Higher components, on the other hand, will depict smaller amplitude variations occurring in fewer images (or over smaller spatial extents). Thus, components 2 and 3 (panels b and c, respectively) are dominated by variations caused by differences in lighting (sun direction and elevation angle) and possibly dust or frost deposition/erosion. RSL features are identifiable in PCA4 (panel d) as elongated blue “fingers” and become more dominant and appear red in PCA5 (panel e). Subsequent components capture smaller variations caused either by changes in lighting, RSL shape (in PCA 8 and 9), or camera noise.

After identifying the PCs which contain the feature of interest, the feature can be traced back to the original images via an inverting from PC coordinates to image coordinates. Although this step is not completely reliable, it is successful in determining which images contain the most prominent RSL. Eventual combination of this method with machine-learning algorithms may permit a more automated means of detecting interesting surface changes on Mars and other planetary bodies. Note this work was previously published in [9].

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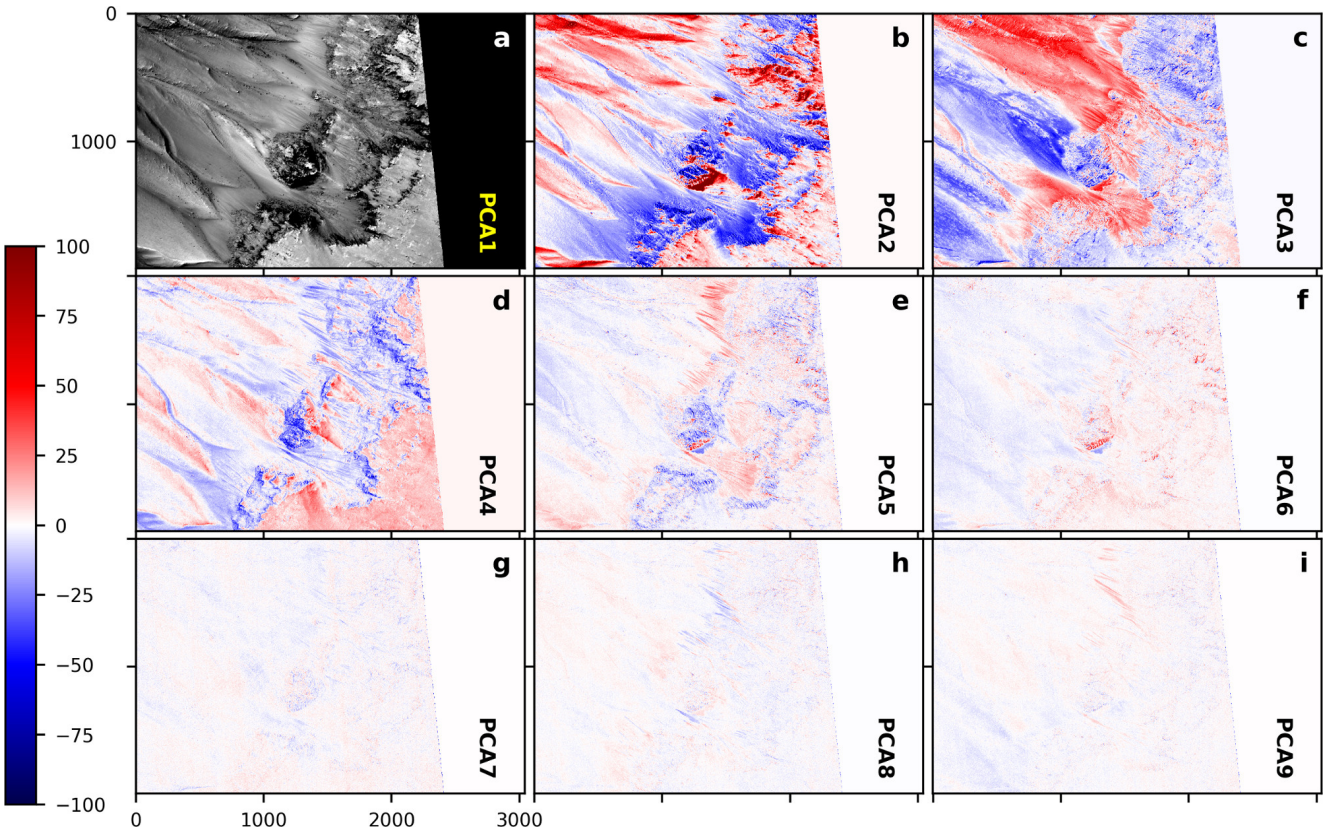
Keywords: Mars, Change, Detection



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Evaluation of the detectability of hydrated salts on recurring slope lineae on Mars.

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On present-day Mars, pure liquid water is thermodynamically unstable; whereas, high-salinity brine can exist on the surface, at least temporally, due to freezing point depression [1]. Deliquescence and melting of subsurface ice are proposed as being the major processes of formation of liquid brine on Mars [2, 3]. Although liquid brine is suggested to form upon Mars' daily and seasonal changes [2, 3], generation of brine flow has not been confirmed on current Mars. Our previous study suggests that cycles of formation and evaporation of liquid brine can generate characteristic morphological features of downward-elongated flows on steep slopes [4]. This happens because precipitated salts within soil dramatically decrease the porosity and permeability, leading generation of surface flows [4]. Our study also suggests that precipitation of salts reaches up to ~30% in volume within the soil, implying that any detection of such salt may be evidence for the occurrence of brine flow on current Mars [4]. Proposed morphological features formed by current brine activity include recurring slope lineae (RSL) [5, 6]. Although hydrated salts are suggested to exist on RSL at a few locations [6], identification of salt compositions is still challenging. Additionally, there are no reports on detection of hydrated salts at most of the RSL sites across Mars.

In the present study, we investigate the conditions of identification of hydrated salt compositions on RSL using Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) onboarded on Mars Reconnaissance Orbiter (MRO). We calculate synthesized spectra of mixtures of basaltic soil and various hydrated salts (such as $MgCl_2 \cdot 2H_2O$) with the different mixing ratios using a linear combination method and an addition of random noise with a Gaussian distribution. We evaluate the threshold mixing ratios of salt for the identification of the salt compositions based on the analyses of the synthesized spectra. Our results show that if the mixing ratio of hydrated salt exceeds 20% in volume, O-H bands attributed from hydrated salts can be detected with CRISM. We discuss the observational conditions, such as the observational altitude from the surface, for the identification of salt compositions on RSL in future missions.

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Keywords: Mars, CRISM, salt

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Frequency of ice sheet growth recorded on Mons Pavonis, Mars

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On present-day Mars, large scale ice bodies are only found at each pole. However, in mid latitudinal areas, LDA (lobate debris apron), LVF (lineated valley fill), CCF (concentric crater fill) are reported and interpreted to have a glacial origin (Levy et al., 2014). Also, inequatorial areas, fan-shaped deposits at northwestern rim of three shield volcanos in Tharsis region though to have a glacial origin (e.g. Fastook et al., 2008).
Fan-shaped deposits sit beside three Tharsis montes and have characteristic geomorphologies extending for roughly 100-500 km from the foot of mountain, typically consisting of three facies: Smooth facies at the top, Knobby facies at the middle, and Ridged facies at the rim. Smooth facies are smooth-surfaced mounds which superpose on other facies, Knobby facies are collective hillocks a few hundred meters in radius, and Ridged facies are linear ridges (moraine-like features) parallel to the rim of the fan. At Arsia (Kadish et al., 2014) and Pavonis (Shean et al., 2005) Mons, ridged facies are especialy well-developed - containing tens to few hundreds of ridges interpreted to be moraines that indicates the varying extent of a former ice sheet. Such geomorphologies potentially record the advance and retreat of ice sheet for tens of kilometers during the Amazonian adjacent to Arsia and Pavonis Mons.
The association of these geomorphologic features to glacial processes is supported by global climate simulations of Mars during high-obliquity (Forget, 2006). The obliquity of the rotation axis of Mars is considered not stable as on the Earth, reaching 45˚ in the past 20 Myrs (Laskar et al., 2004). Such high obliquity can cause sublimation of the polar cap, enhancing the water vapor content in the atmosphere compared to present-day Mars. By diffusion and condensation model, Mellon & Jakosky (1995) found that in the surface environment of present-day Martian obliquity (25.2˚) water ice is stable only at 40˚ latitude or higher, however, when obliquity gets higher than 32.3˚, with enough amount of atmospheric water vapor, water ice becomes stable globally. This result suggests Martian surface environment has experienced such climate condition that water ice condenses and deposits in mid and low latitudinal areas. Therefore, the existence of Martian “ice age” during Amazonian high-obliquity periods is being proposed (Head et al., 2003).
If ice sheet growth and disappearance on the flanks of Tharsis Montes are an indication of the climate change caused by orbital parameters, each of moraine-like features should correspond to a paleoclimate cycle. However, fluctuation of its spacing, scale and correlation to orbital parameter have not yet been discussed. Hence, as basic study to associate distribution of moraine-like features to extent of the ice sheet, we made DEM data from CTX imagery at the rim of fan-shaped deposits at the foot of Mons Pavonis, and using the DEM data, we measured spacing and cross-sectional area of each moraine, and conducted frequency analysis on the cross section of DEM data.
As a result, spacing of moraine-like feature appeared to fluctuate from few hundred meters to 4.5 km, showing drastic change of the density. Also, cross sectional area of moraine-like feature fluctuates up to 1.4×10^4 m^2. These fluctuations potentially record the change of frequency of events that caused accumulation and ablation of ice sheet or change of velocity of ice sheet flow. In Tharsis region, these two periodic events are assumed to affect ice sheet: global climate change caused by orbital parameter, and local volcanic activity. To prove the spacing and moraine-size are driven by global climate forcings, there should be similarities between the ridges found at Pavonis, Arsia, and a correlation to orbital parameters. Therefore, frequency analysis of cross- sectional view of the terrain is being conducted. The result will be shown in the presentation.

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Keywords: Mars, Martian climate, Tharsis region, Milankovich cycle

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Development of Life Detection Microscope (LDM) for *in situ* imaging of living cells on Mars surface

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Past trial of direct detection of life on Mars by 1970's Viking mission ended up with a negative conclusion [1]. Whereas, numbers of new finding provided by Mars exploration missions in the last decade indicate that there are good reasons to perform another life detection program. The sensitivity of the gas chromatograph mass spectrometer onboard the Viking mission was not very high, and was not able to detect the microbes 10^6 cells in 1 gram clay [2,3]. Resent observations on Mars have found the evidences of past water activities. MSL Curiosity has found the temporal increase of methane concentration in Martian atmosphere [4]. The presence of reduced sulfur compound such as pyrite in Martian soil was also detected by MSL [5]. Methane and reduced sulfur compound can be the energy source to support the growth of chemoautotrophic microbes [6]. Possible presence of liquid water at Recurring Slope Lineae has been supported by the detection of hydrated salts [7]. The presence of organic compounds of Martian origin has been reported [8]. These evidences tend to support the possible presence of living microbes near the surface of Mars.

Physical and chemical limits for terrestrial life have been major foci in astrobiology [9], and are summarized in ref. [6]. Combining the environmental factors, anywhere in the Martian environment where we can find the three components, water molecules, reducing compounds and oxidative compounds could be an environment where life can be sustained for long periods of time, if other factors such as temperature, pressure, UV and other radiations permit [6]. Among these factors, most of the factors including ionic radiation, can be endured by terrestrial extremophiles. Only UV can kill the most UV-resistant microbes within minutes. However, UV can be shielded by a few centimeters soil layer. These evaluations lead to the conclusion that the Martian soil under a few cm can be the place to support the growth of microbes, if the water activity is higher than 0.6.

For exploring extant life on Mars, we have proposed to search cells from a depth of about 5 - 10 cm below the surface by the Life Detection Microscope (LDM) [6, 10]. LDM has the potential to detect single cells in the resolution of 1 micrometer and could detect less than 10^4 cells in 1 gram clay, which is much higher sensitivity than the instrument onboard Viking. We have developed the solution and combination of fluorescence pigments to detect organic compounds, and to differentiate organic compounds surrounded by membrane, which we think to be the most fundamental features that a cell should possess to constitute life. Our investigation goals are the followings. 1) Identify cell-like structure in which organic compounds are enveloped by membrane, which may represent Martian life. 2) Search for any type of organic compounds in Mars surface samples. The compounds include cells, other biological materials, and abiotic polycyclic aromatic hydrocarbon (PAH). 3) High-resolution characterization of regolith and dust particles. The current status of development of LDM will be presented.

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Keywords: fluorescent microscope, extraterrestrial life

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Development of a Mars Web-GIS for viewing multiple kinds of spectral data from orbiters

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The VIS-NIR reflectance spectra observed during latest Mars orbiter missions are of high quality and cover the whole globe. Such data sets are very informative for understanding the materials and their distribution on the surface. Each mineral has unique absorption bands in the spectra. We can identify which minerals are present by comparing the absorption bands of the observed spectra with the known absorption bands in the spectra measured in laboratories. In the case of Mars, we can estimate the type and distribution of hydrous minerals which leads to important clues to understand the water environment.

However, the VIS-NIR spectral data observed on Mars are not well utilized among the community. There are huge volume of accumulated data due to an increasing number of missions and various kinds of instruments with higher accuracy. It is not easy to process huge data and understand the relevance of them visually and intuitively.

We develop a new Mars web-GIS application, "Red Ace", to view and download the Mars observation data, especially the VIS-NIR spectra (image cube data format), easily and intuitively. The Red Ace handles multiple kinds of observation data: the Compact Reconnaissance Imaging Spectrometers for Mars (CRISM) data, the Thermal Emission Imaging System (THEMIS) data and DEM (Digital Elevation Model) data at the same time. Additionally, we use the DEM data from the Mars Orbiter Laser Altimeter (MOLA) to display 3D map of Mars with the Red Ace.

The Red Ace is developed based on CesiumJS that is an open source JavaScript library for 2D/3D maps. The user can choose the dimension of the map. In the Red Ace, the spectral observation points are displayed on the surface image layers. When the user clicks any point on the footprint of the layer, the color of the selected footprint changes and the thumbnail image appears. When the user selects any pixel on the thumbnail image, the Red Ace provides reflectance spectral data and ancillary data as graphs and tables. In response to user operation, multiple kinds of spectral data are displayed on the same window. The Red Ace also provides band- ratio images of THEMIS. The user can download band-ratio images, spectral data and ancillary data as files of PNG, CSV, JSON, XLSX and PVL formats. The user can move the windows displaying thumbnail image and graph freely. In addition, the Red Ace provides the function to control the Mars base map changing the exaggeration of height of the Mars globe. The user can change the order of layers and transparency of layers arbitrarily. The user can also jump to the region of interest directly by setting the coordinates and the zoom level. The user can handle these functions smoothly.

In the case of THEMIS, published data from the mission data archive are not reflectance data but radiance data. Therefore, the Red Ace derives reflectance data from radiance data and ancillary data, in order to compare them with CRISM spectra observed in the same spot.
In this study, considering the portability and extension of the application, the Docker was used for the development environment. Docker is an open source software platform that allow the user to develop applications quickly using containers. JSON format is adopted for data handling to make it easier to add new observation data from new observation equipments in the future. In the JSON format, it is unnecessary to associate item order and item meaning. Hence, it has high reusability and freedom. In the

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Red Ace, by standardizing the structure of JSON format data in advance, it is possible to store and handle diverse data by using the same data structure.

Keywords: Mars, Spectral data, Web-GIS

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Visualization and Analysis of the Surface of Mars with NASA's Mars Trek Portal

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Originally released in June, 2015 as a public outreach tool, Mars Trek is currently being enhanced to support site selection and analysis for upcoming human and robotic missions to Mars. Many new data products are being added, with emphasis on providing detailed information for proposed exploration zones. Data products can be loaded and even combined from many different instruments aboard many different Mars-orbiting spacecraft including Viking, Mars Global Surveyor, Mars Odyssey, Mars Reconnaissance Orbiter, and Mars Express. Users can download data products from Mars Trek and access metadata for each product. Web services and APIs allow other clients to access data from Mars Trek's servers. A standardized interface across the Trek portals provides for advanced 3D visualization and navigation. Standard keyboard gaming controls allow the user to maneuver a first-person visualization of "flying" across the surface of the Mars. User-specified bounding boxes can be used to generate STL and/or OBJ files to create physical models of surface features with 3D printers. A new VR capability allows users to generate their own virtual reality flyovers for any user-defined paths along the Mars' surface.

Mars Trek's power as a tool for education and outreach is exemplified by its being designated as key supporting infrastructure for NASA Science Mission Directorate's STEM Activation Initiative, and its serving of data to a growing community of digital planetariums.

As private industry and space agencies of a growing number of nations plan new missions to Mars, detailed maps and models of Mars' surface and climate will be essential for mission planning. Mars Trek's generalized suite of tools are being designed to meet the needs of this new generation of missions. The portal will also provide an outstanding means of dissemination of data from these missions. Layering and blending many different data products and putting individual products in the context of many others will facilitate mining of information going far beyond what individual products can provide separately. In addition to mission planning and planetary science, Mars Trek will continue supporting the essential task of engaging the public in this great adventure. Mars Trek is developed at NASA's Jet Propulsion Laboratory (JPL) and managed as a project of NASA's Solar System Exploration Research Virtual Institute (SSERVI) at NASA Ames Research Center.

At the request of the Planetary Science Division of NASA's Science Mission Directorate, we are extending the technologies of our existing Trek platforms to create a new portal for Mars' largest moon, Phobos. In this effort, we are working with the International Phobos/Deimos Landing Site Working Group and with JAXA, with JAXA's MMX mission as a primary driver.
Mars Trek is one of the portals in the NASA Solar System Treks Project (SSTP), available at https://trek.nasa.gov. NASA's Solar System Trek online portals provide web-based suites of interactive data visualization and analysis tools to enable mission planners, planetary scientists, students, and the general public to access mapped data products from past and current missions for a growing number of planetary bodies including the Moon, Mars, Vesta, etc. These portals are being used for site selection and analysis by NASA and a number of its international partners, supporting upcoming missions. In addition to demonstrating the capabilities of Mars Trek in this presentation and providing a preview of Phobos Trek,

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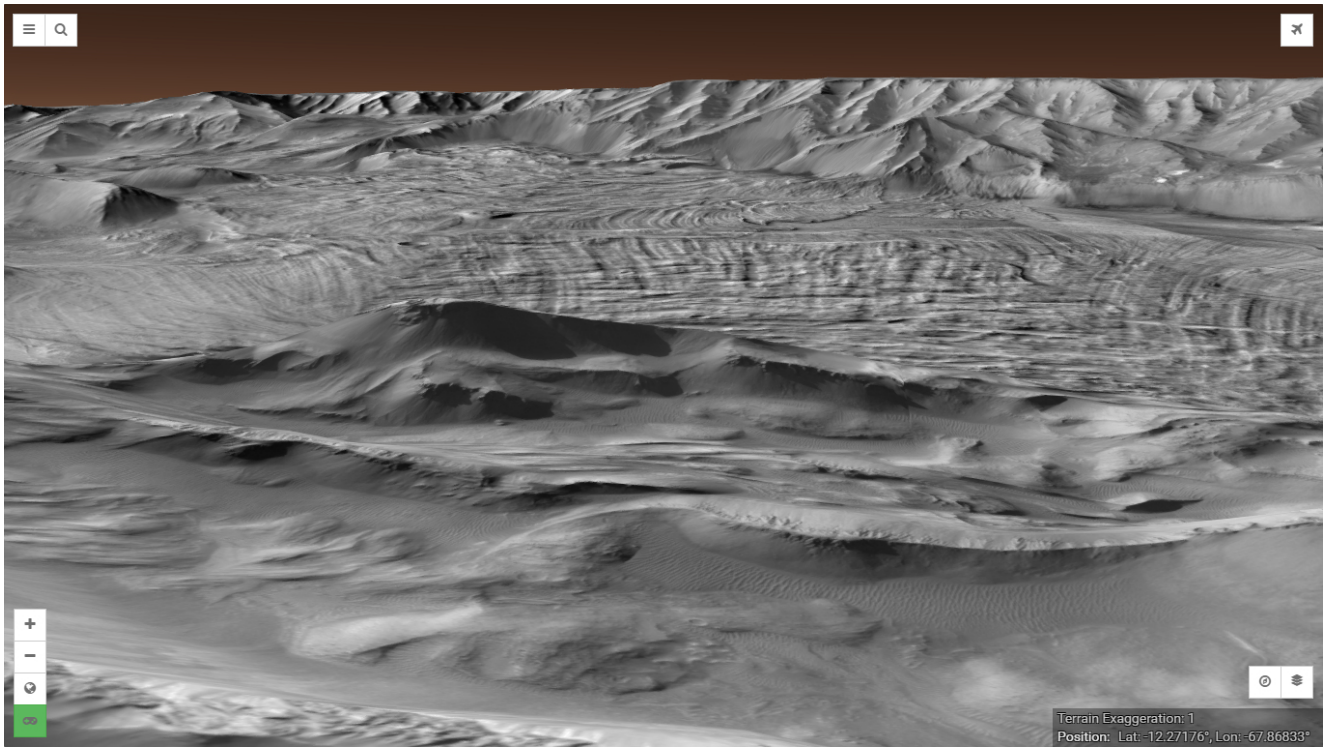
we will solicit input from the community for ideas for future enhancements to the portals.

Keywords: Mars



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Increase in Dissolved Iron Concentration from Fayalite by UltravioletA・C Irradiation

*Nobuo Komori[1]

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To investigate the mystery of “Why the Mars' surface with poor oxgen has so much iron oxide" I have led student experiments at junior high schools. I will show my recent experiments and their results.
A.S.Yen (1999) showed that reactive oxygen species can also be formed on mineral grains under Martian conditions by irradiating ultraviolet C to quartz samples. Furthermore he irradiated ultraviolet C to thin iron films in the air and showed that exposure to ultraviolet radiation increases the rate of oxide formation. My experiments was irradiating ultraviolet A and C to fayalites and iron in acid water. This results indicated the possibility that iron oxides might be formed because of ultraviolet rays other than the cause of reactive oxygen species in the past.
Experiment no.1:
I had students irradiate ultraviolet rays A and C to Fayalite in hydrochloric acid.I had students irradiate ultraviolet rays A and C to Fayalite in hydrochloric acid. In this experiment, I used Fayalite from Kawamata-machi, Fukushima.
Fayalite, which is about 1g and not formatted was put in the test tube in the test tube filled with hydrochloric acid pH2.After the experiment, I had students check the concentration of iron ions in the water solution by using a digital pack test. This experiment with ultraviolet rays A was carried out 7 times and the experiment with ulttaviolet rays was carried out 3times.According to the results of the experiment with ultraviolet rays A, the quantity of iron elution increased more in the case of ultraviolet rays irradiating 6 times out of 7 than with the result of no irradiation.The results of the experiment with ultraviolet rays C were idential (3 times out of 3). The peak of wavelength ultraviolet rays A is generated by black lite is 365 nm. The peak of wavelength ultraviolet rays C is generated by germicidal lamp is 245 nm.
Experiments no.2:
I had the students irradiate ultraviolet rays A to a battery that has the iron cathode copper anode in hydrochloric acid. The Students then measured the occured voltage of the battery. I compared the voltage between ultla violet rays irradiation and non irradiation.The irradiated battery’s voltage stayed over 0.2V and the voltage did not decrease after 150hours.Another non-irradiated battery’s voltage decreased lower little by little and the voltage was close to 0V after 150 hours.This experiment was carried out 4times. In all cases the voltage of the battery that was irradiated by ultraviolet rays was higher than the non-irradiated battery.
It seems that electrons dissociate from iron atoms by ultlaviolet energy and form iron ions.
Consideration
From my experiments results, I would infer that ultraviolet rays advance the dissolution of iron ion from fayalite and iron. I think ultraviolet rays are one of the causes of iron oxide and hidroxide existing on Mars’ surface besides reactive oxygen species.It seems that there was water on Mars’ surface. There was a possibility that advancing of iron dissolution from rocks on Mars by ultraviolet rays irradiation.

Keywords: ultraviolet rays, fayalite , hydrochloric acid, iron, elution increase

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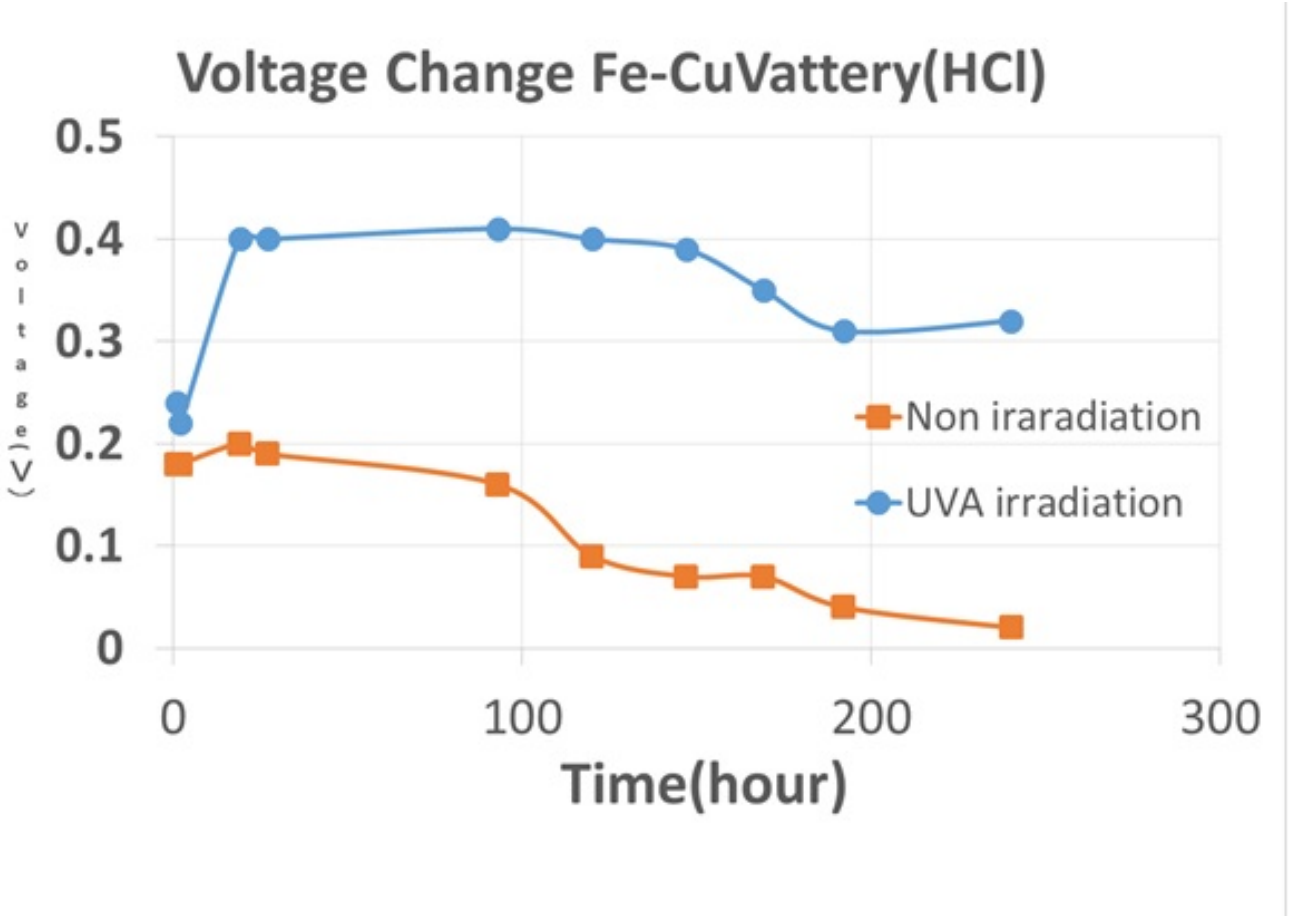

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Small-scale ridges newly identified on the equatorial region of the Phobos nearside

*Ryodo Hemmi[1], Hiroshi Kikuchi[1], Hideaki Miyamoto[1]

1. The University of Tokyo

Although the craters and grooves on Phobos are indicative of widespread and abundant surface modification during Phobos' geologic history [Basilevsky et al., 2014], little definitive evidence exists for geologically recent regolith migration other than down-slope mass-wasting [Shi et al., 2016]. Here we report newly found small-scale sinuous ridges identified in Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment (HiRISE [McEwen et al., 2007]) images of the nearside of Phobos. These ridges are spatially focused within the equatorial region (-5° to 20° N). Some of them superpose on craters and grooves, which is consistent with a geologically recent activity. They are ~200 m to ~1 km in length, several 10's m in width, and most of them are roughly parallel to each other and are generally oriented in NE-SW direction. To extract detailed topographic profiles, we constructed a high-resolution (~5-6 m/pixel; almost same as the original image) digital elevation model (DEM) by using shape-from-shading [Alexandrov and Beyer, 2018] in the selected regions of a HiRISE image and a stereo-derived HiRISE DEM (20 m/pixel) [Hemmi and Miyamoto, 2019]. Our preliminary analysis shows these ridges are less than several meters high. Their morphology and topography are unlikely to be formed by impact cratering, extensional stress fields, or mass wasting processes. In this presentation, we provide initial results of geological mapping of the small-scale ridges and discuss their possible origins.

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Keywords: Phobos, HiRISE, Digital Elevation Model

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Development of a compact Muography instrument for future Mars exploration missions

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Muography is a technique that uses cosmic ray muons for visualizing the interior of large-scale structures in much the same way as standard X-ray radiography is used to image the interior of smaller objects. Muography has been successfully applied to explore the internal structure of geological targets on earth. Because exploring the inner structure of the shallow subsurface of celestial bodies is important to understand their origin and evolution, we are planning to operate muography instrument in the extraterrestrial environment, especially on the surface of Mars. Applying muography to planetary explorations has some advantages over conventional internal exploration methods: (1) it is able to observe the absolute linear density of objects; (2) the passive nature of the measurements provides low power consumption; (3) the instrument size is arbitral [1]. However, in order to mount muography instrument on a spacecraft, it is essential to downsize the instrument and investigate the radiation environment on the surface of the celestial body. In this study, we designed and developed a compact muography instrument based on the knowledge of compact gamma ray detectors for nuclear medicine imaging. At the same time, we theoretically estimated the muon production on Mars and evaluated the validity of using muography instrument on Mars.

The detection device of developing muography instrument consists of 64-channel silicon photomultipliers (SiPM), plastic scintillators, dynamic Time-Over-Threshold (dTOT) boards [2], data-acquisition (DAQ) board, and high-voltage power supply units. Incident muons react with the scintillator to emit weak light, and the light is amplified by SiPM attached to the both ends of the scintillator and read out with dTOT boards. The depth of interaction (DOI) in the scintillator is analyzed by measuring the pulse-height ratio of dual-sided readout. The size of the detector is 26.2 mm×26.2 mm×31.4 mm.

We first evaluated DOI resolution of this detector using a point beta-decay source of ^{90}Sr. The result indicates that the DOI resolution (FWHM) is 7.2 mm for the emitted beta rays with a spread of 2.2 mm. Then, we performed a Geant4 [3] simulation to examine the muon angular distribution that would be detected on the ground by this instrument. The result suggests that the structure of the detector makes the observation bias (Fig. 1). There are two solutions that can be considered to solve this problem: (1) developing one more detector and analyzing the coincident signals from dual-sided readout; (2) improving DOI resolution by performing accurate calibration.

We also performed a theoretical estimation to evaluate the muon production on Mars. Although the chemical composition and the density of Martian atmosphere are different from Earth's, the known muon flux in the upper earth atmosphere can be used for estimating the muon rates on Mars [4]. The result shows that the horizontal muon flux is greater than that on Earth (Fig. 2), which means that muography is more suitable for exploration of geological targets on Mars than on Earth.

In this presentation, we report the development status of the detection device and the concrete result of numerical calculation of radiation environment on Mars.

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Keywords: Muography, Muon, Internal exploration, Mars exploration

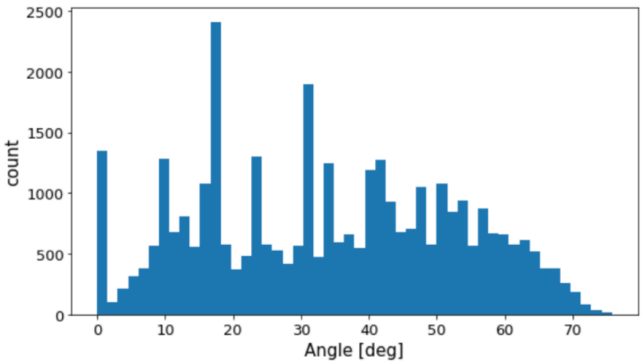

Fig. 1 The simulation result of muon zenith angular distribution that would be detected by developing instrument. The structure of detector makes the observation bias at 0°, 17° and 31°.

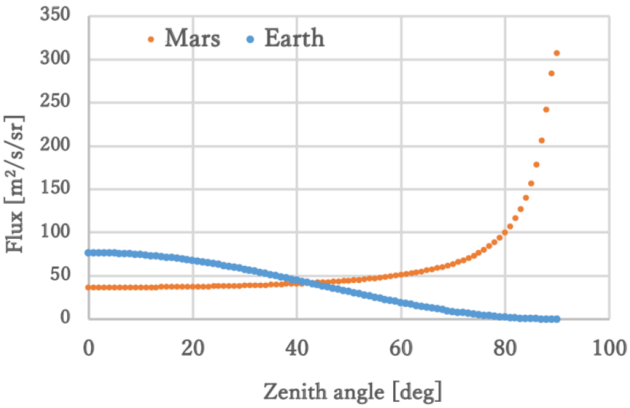

Fig. 2 Zenith angle dependence of muon flux on Mars and Earth. Horizontal muon flux on Mars is greater than that on Earth.

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[E] Poster | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_4

[P-PS04] Mars and Mars system: results from a broad spectrum of Mars studies and aspects for future missions

convener:Hideaki Miyamoto(University of Tokyo), Tomohiro Usui(Earth-Life Science Institute, Tokyo Institute of Technology), Ayako Matsuoka(Research Division for Space Plasma, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Sushil K Atreya(University of Michigan Ann Arbor)

In view of unprecedented advances in our understanding of Mars, primarily due to new and ongoing observations of the planet with a number of spacecraft missions of the US, Europe and Asia, we propose a session on Mars. Mars is an object of intense scrutiny. Currently, eight spacecraft are operating at Mars, with six in orbit (Odyssey, MRO, MAVEN, Mars Express, Mangalyaan and TGO) and two on the surface (MSL-Curiosity and MER-Opportunity), the largest number ever at any given time. In addition, InSight is on track to land on Mars in November 2018, and several spacecraft are in various stages of implementation with launches scheduled for 2020 (Mars 2020, ExoMars 2020, Emirates Mars Mission Hope, Chinese Mars Mission and the Japanese Mars Terahertz Microsatellite), 2022 (ISRO's Mangalyaan 2), and 2024 (JAXA's MMX mission to explore Phobos, Deimos, and Mars). All this is a clear demonstration of public's strong fascination with and commitment to Mars exploration and the resulting scientific bonanza. Synergistic investigations with ongoing and already completed missions along with modeling studies and earth-based observations are gradually revealing the nature of Earth's most closely resembling planet that took on a different evolutionary track than our home planet. Morphology and variable phenomena seen on the surface (RSLs, e.g.) and in the atmosphere (methane) indicate that Mars is possibly currently active. Available data are providing a better understanding of Mars' present geologic and atmospheric state, climate evolution, and habitability. Thus, the scope of this session will be the recent results from a broad spectrum of Mars studies encompassing the interior, surface, atmosphere, plasma environment, and the Mars system including its two satellites. Abstracts on modelling, instrumentation and future mission plans are also encouraged.

[PPS04-P01] Observation of the O_2^+ first negative band (1,0) emissions in the Mars ionosphere with a visible spectrograph on Haleakala T60

*Toshihisa Suzuki[1], Masato Kagitani[1], Takeshi Sakanoi[1] (1.PPARC, Graduate School of Science, Tohoku University)

[PPS04-P02] Search of shallow subsurface reflectors around RSLs in Martian Chryse and Acidalia planitiae by the MRO/SHARAD public data

*Aina Oura[1], Yasumasa Kasaba[1], Atsushi Kumamoto[1], Rina Noguchi[2], Tomohiro Usui[2], Ken Ishiyama[2], Chihiro Uemura[3] (1.Tohoku University, 2.Institute of Space and Astronautical Science, 3.SOKENDAI)

[PPS04-P03] Detecting surface changes on Mars using principle component analysis of repeat imagery

*Reid Parsons[1], Hideaki Miyamoto[1] (1.University of Tokyo)

[PPS04-P04] Evaluation of the detectability of hydrated salts on recurring slope lineae on Mars.

*Shoko Imamura[1,2], Yasuhito Sekine[2], Hiroyuki Kurokawa[2] (1.University of Tokyo, 2.Earth-Life Science Institute, Tokyo Institute of Technology)

[PPS04-P05] Frequency of ice sheet growth recorded on Mons Pavonis, Mars

*Tomohiro Kanzaki[1], Reid Parsons[1,2], Ryodo Hemmi[1], Hideaki Miyamoto[1] (1.University of Tokyo, 2.Fitchburg State University)

[PPS04-P06] Development of Life Detection Microscope (LDM) for *in situ* imaging of living cells on Mars surface

*Yoshitaka Yoshimura[1], Akihiko Yamagishi[2], Takehiko Satoh[3], Atsuo Miyakawa[2], Eiichi Imai[4], Satoshi Sasaki[5], Kensei Kobayashi[6], Yoko Kebukawa[6], Tomoka Okada[6], Keigo Enya[3], Hikaru Yabuta[7], Takeshi Naganuma[7], Hajime Mita[8], Kazuhisa Fujita[3], Tomohiro Usui[3] (1.College of Agriculture, Tamagawa University, 2.Tokyo University of Pharmacy and Life Science, 3.Japan Aerospace Exploration Agency, 4.Nagaoka University of Technology, 5.Tokyo University of Technology, 6.Yokohama National University, 7.Hiroshima University, 8.Fukuoka Institute of Technology)

[PPS04-P07] Development of a Mars Web-GIS for viewing multiple kinds of spectral data from orbiters

*Yuya Matsubara[1], Hironori Fukuchi[1], Yoshiko Ogawa[1], Yohei Hayashi[2] (1.The University of Aizu, 2.National Astronomical Observatory of Japan)

[PPS04-P08] **Visualization and Analysis of the Surface of Mars with NASA's Mars Trek Portal**

*Brian Hamilton Day[1], Emily Law[2] (1.NASA Solar System Exploration Research Virtual Institute, NASA Ames Research Center, 2.NASA Jet Propulsion Laboratory, California Institute of Technology)

[PPS04-P09] Increase in Dissolved Iron Concentration from Fayalite by UltravioletA・C Irradiation

*Nobuo Komori[1] (1.The United Graduate School of Education Tokyo Gakugei University)

[PPS04-P10] Small-scale ridges newly identified on the equatorial region of the Phobos nearside

*Ryodo Hemmi[1], Hiroshi Kikuchi[1], Hideaki Miyamoto[1] (1.The University of Tokyo)

[PPS04-P11] Development of a compact Muography instrument for future Mars exploration missions

*Hiroaki Kamiyoshihara[1], Tetsuro Ninomiya[1], Yuri Yoshihara[1], Kenji Shimazoe[1], Hiroyuki Takahashi[1], Hiroyuki Tanaka[1], Hideaki Miyamoto[1] (1.University of Tokyo)

Observation of the O_2^+ first negative band (1,0) emissions in the Mars ionosphere with a visible spectrograph on Haleakala T60

*Toshihisa Suzuki[1], Masato Kagitani[1], Takeshi Sakanoi[1]

1. PPARC, Graduate School of Science, Tohoku University

We carried out ground-based telescope observations of Martian ionospheric O_2^+ emission to obtain global distribution of Martian O_2^+ ionosphere and its variation for understanding Martian atmospheric escape process. After verifying the analysis method, the result suggests that the O_2^+ first negative bands (1NG) (1, 0) emissions are successfully detected, and calculated O_2^+ emission intensity and column density.
Mars has tenuous atmosphere compared with the Earth. One possible model for Martian tenuous atmosphere is caused by atmospheric escape to space for a long time. In addition, present Mars has only weak crustal magnetic fields for limited area, and therefore, it is likely that solar wind strongly affects Martian atmosphere escape. In recent years, ion composition and densities in the Martian ionosphere are revealed by Mars probes (e.g. Mars Express, MAVEN). In the Martian ionosphere, main ion is O_2^+ [M. Benna et al., 2015]. Moreover O_2^+ recombines with an electron, and as a result of a neutral molecule dissociation, neutral atomic oxygens are generated. Since the neutral atomic oxygen energy is higher than escape velocity of Mars, it can be escaped from Martian gravity. This process is important in Martian atmosphere escape. However, it is difficult to detect atomic oxygen by Mars probe in-situ observation, and escape quantity is indirectly estimated by plasma temperature and density from in-situ observations. On the other hand, remote-sensing of Martian ionosphere is useful to obtain global distribution and its time and spatial variations. It is essential to combine in-situ plasma data with global remote sensing for understanding Martian atmospheric escape, such as solar wind impact and/or crustal magnetic field effect on the escape process.
We carried out Martian ionosphere O_2^+ emission observation using Tohoku University T60 telescope (located at the summit of Mt. Haleakala in Maui) with Vispec (Visual imager and Spectrograph with Coronagraphy) from September 10 to 19, 2018. This is the first attempt to detect Martian O_2^+ emission with a ground-based telescope. We focused O_2^+ 1NG (1, 0) bands emission with a peak wavelength of about 561 nm. Visible Echelle spectrograph Vispec (wavelength resolution was 10,000) covered wavelength range from 550 nm to 570 nm. Vispec slit (width 2” ×length 90”) was located near Martian dayside limb parallel to the Martian rotation axis, and exposure time of one frame was 2 minutes. Total exposure time in observation period was 450 minutes. To refer sunlight spectrum reflecting by Martian surface, we acquired spectrum of disk center by Martian surface. First analysis process (subtraction dark, revision by flat-field, wavelength and space) was conducted on each frame, and each frame was added to gain S/N. Finally, sunlight spectrum was subtracted using disk center to obtain O_2^+ 1NG (1, 0) bands emission spectrum. Next, we compared observed O_2^+ spectrum with O_2^+ 1NG (1, 0) model spectrum given by Henriksen and Veseth [1987]. Focusing on only short period wavelength variations, we performed high-pass filter analysis on the both of observed and model spectrum. After that, we calculated the correlation coefficient between observed spectrum and model spectrum, and found that the coefficient maximum is 0.40 with no wavelength lag between two spectra. Data points, i.e., wavelength range, using correlation coefficient analysis were selected so that model O_2^+ emission is relatively intense and the contamination of solar fraunhofer absorption line is negligible. We estimated O_2^+ 1NG (1, 0) emission intensity with a least-square method to be 691 +/- 171 $\times 10^3$ Rayleighs, and the column density to be 4.4 +/- 1.1 $\times 10^{13}$ /cm^2. The estimated column density was greater than that of simulation. In this presentation, we compare O_2^+ emission observation spectrum with model spectrum, and give the estimation of O_2^+ emission intensity and column density in detail. We also give discussion about the

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results.

Keywords: Mars, ionosphere, ground-based telescope

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Search of shallow subsurface reflectors around RSLs in Martian Chryse and Acidalia planitiae by the MRO/SHARAD public data

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One of recent discoveries on Mars is the recurring slope lineae (RSL), which are certain features on the surface invoking current icy processes. RSLs are distributed on Mars and these narrow features incrementally lengthen down steep slopes, fade in colder seasons, and recur annually. Candidate and confirmed RSL sites are distributed in four regions, (1) southern mid-latitudes (SML), (2) Valles Marineris (VM), (3) equatorial highlands, and (4) northern Chryse Planitia and southwestern Acidalia Planitia (CAP). The RSLs in (2) VM and (4) CAP are more densely located than other two areas.
This study tries to identify the subsurface structures of the northern mid-latitude RSL in (4) Chryse and Acidalia Planitiae by the public data of Mars shallow radar sounder (SHARAD) onboad the Mars Reconnaissance Orbiter opened on the PDS Geosciences Node. That is because CAP RSLs are densely distributed compared to other regions. CAP RSLs are found on the steep slopes of craters. Their source zones are at or below the elevation of the surrounding plains. We used the Java Mission-planning and Analysis for Remote Sensing (JMARS, https://jmars.asu.edu/) in order to investigate the geological information of the RSL sites and the MRO locations at the SHARAD observed data. We then picked up the location correspond to the RSL sites and generated radargrams from SHARAD data. The observation frequency of SHARAD is 15-25 MHz with the bandwidth of 10 MHz, and the subsurface close to the surface can potentially be resolved with the depth resolution of 15 m in vacuum. Using MOLA data, we generated the virtual radargrams with the surface clutter emulated by the Kirchhoff approximation. Then, we compared both observed radargrams with emulated ones to identify whether there are subsurface reflectors or not.
We surveyed about 12 orbits close to the confirmed RSLs. We could find the hypothetical detection of the subsurface reflector in ‘orbit.00688101’ (Jan 14 2008, N10.0-44.7˚, E313.6-318.3˚) and ‘orbit.00673602’ (Jan 03 2008, N10.1-44.7˚, E312.7-317.4˚). In this abstract, we concentrated the characteristics of the former candidate. In this sample, the closest RSL located at N34.1˚, E317.0˚ and nadir line from the orbit was 13.8 km. Another RSL close to this orbit located N34.8˚, E318.6˚ and nadir line from the orbit was 85.2 km. Apparent elevation of closest RSL was about -3,763 ±10 m. The deepest elevation of the crater was about -4,744 ±10 m and the highest elevation of it was about -3,640 ±10 m. The radargram of this orbit showed that the elevation of surface echo was in the range from -3720 to -3780 m and that of subsurface echo ranged from -3750 to -3800 m. This means that the closest RSL height was almost the same as the depth of subsurface reflector. The subsurface echo located 25 m below the surface, and it had a little bit weak echo strength compared to surface one. If this subsurface echo shows the underground reflection, the subsurface layer will be 180 km wide along the orbit. Although this depth is marginal for the depth resolution of SHARAD, we could not identify such an echo in the emulated radargram.
In the presentation, we will summarize the results of this region including other orbits.

Keywords: Mars, RSL, SHARAD

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Detecting surface changes on Mars using principle component analysis of repeat imagery

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Change detection is an analytical tool of Remote Sensing in which repeat observations of a particular location can be overlain, subtracted, or ratioed to detect differences between images. High-resolution, repeat imagery on Mars has led to several discoveries of ongoing geologic processes operating at the sub-kilometer scale such as recurring slope lineae (RSL) [1-3], new, small impacts [4], aeolian dune migration [5], sublimation of polar ice [6], and gully formation [7]. Generally, the detection of these changes is done manually by overlaying, and “flipping” between the two images. As planetary remote sensing data sets continue to grow, so does the need for a more efficient means of change detection.

Principle component analysis (PCA) offers an advantageous means for detecting change because it considers the values of all pixels in all the repeat images to extract the most statistically significant variations. These variations are then isolated from one another as a hierarchical set of “principle components” of the image dataset. The user can quickly identify patterns or features of interest which are present in one or more of these components. To illustrate this method, nine HiRISE images [8] collected from Palikir crater on Mars between November 2007 and June 2011 documenting RSL formation will be used.

PCA changes the values of the pixels in each image by plotting the pixel data on a set of axes which capture the maximum variance in the dataset. In our example image set, each pixel in the image stack can be treated as a 9-dimensional vector since there is a value for that pixel in each of the nine images. However, each pixel can be plotted on a new set of axes that capture the most important, or PCs of the image stack.

The figure shows the result of the PC transform (performed using ENVI® software) on the stacked time-series. Because most of the variation in the images is captured in the first PC (PCA1), it uses a grayscale color bar spanning 0-255 pixel values. Generally, variations covering a large spatial extent or variations causing a big shift in pixel values will be captured in the lower PCA components. Higher components, on the other hand, will depict smaller amplitude variations occurring in fewer images (or over smaller spatial extents). Thus, components 2 and 3 (panels b and c, respectively) are dominated by variations caused by differences in lighting (sun direction and elevation angle) and possibly dust or frost deposition/erosion. RSL features are identifiable in PCA4 (panel d) as elongated blue “fingers” and become more dominant and appear red in PCA5 (panel e). Subsequent components capture smaller variations caused either by changes in lighting, RSL shape (in PCA 8 and 9), or camera noise.

After identifying the PCs which contain the feature of interest, the feature can be traced back to the original images via an inverting from PC coordinates to image coordinates. Although this step is not completely reliable, it is successful in determining which images contain the most prominent RSL. Eventual combination of this method with machine-learning algorithms may permit a more automated means of detecting interesting surface changes on Mars and other planetary bodies. Note this work was previously published in [9].

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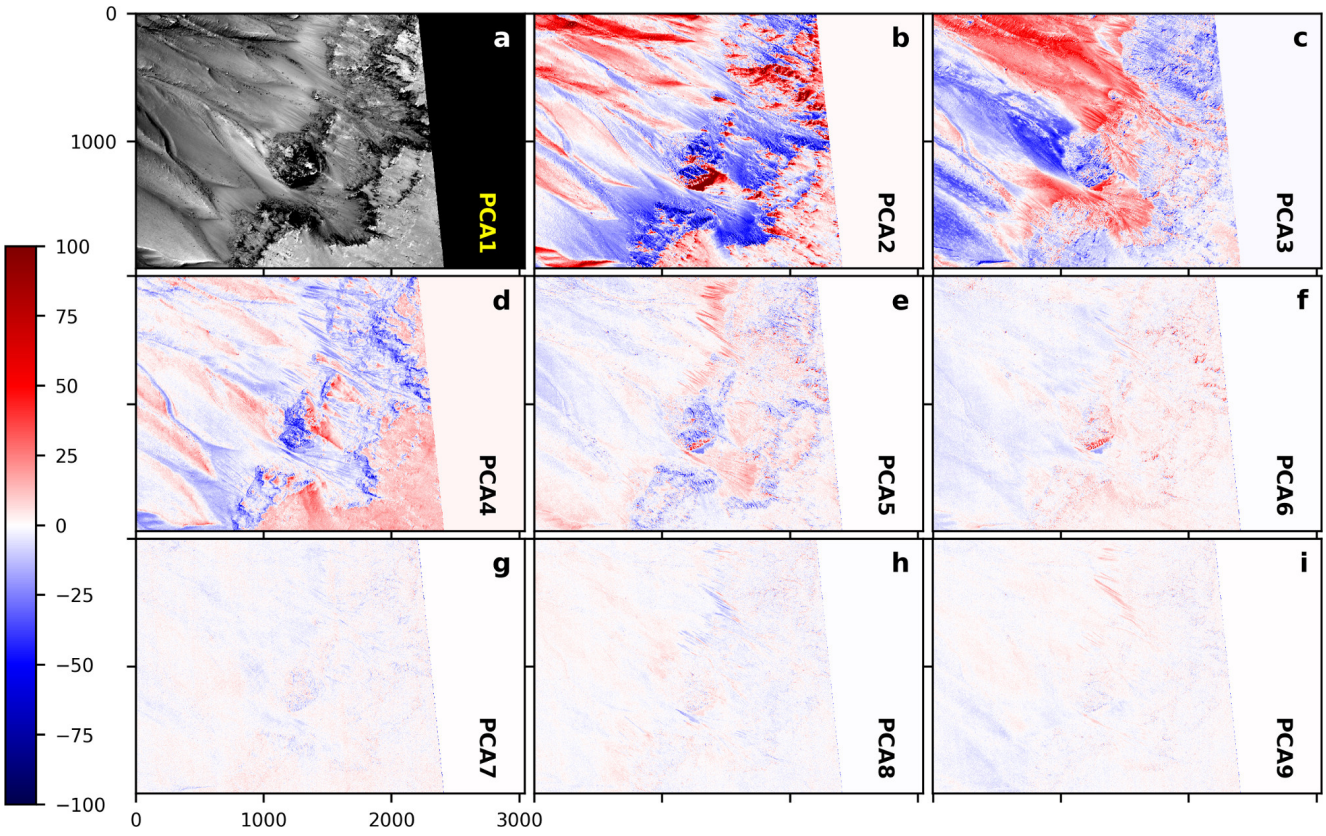
Keywords: Mars, Change, Detection



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Evaluation of the detectability of hydrated salts on recurring slope lineae on Mars.

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On present-day Mars, pure liquid water is thermodynamically unstable; whereas, high-salinity brine can exist on the surface, at least temporally, due to freezing point depression [1]. Deliquescence and melting of subsurface ice are proposed as being the major processes of formation of liquid brine on Mars [2, 3]. Although liquid brine is suggested to form upon Mars' daily and seasonal changes [2, 3], generation of brine flow has not been confirmed on current Mars. Our previous study suggests that cycles of formation and evaporation of liquid brine can generate characteristic morphological features of downward-elongated flows on steep slopes [4]. This happens because precipitated salts within soil dramatically decrease the porosity and permeability, leading generation of surface flows [4]. Our study also suggests that precipitation of salts reaches up to ~30% in volume within the soil, implying that any detection of such salt may be evidence for the occurrence of brine flow on current Mars [4]. Proposed morphological features formed by current brine activity include recurring slope lineae (RSL) [5, 6]. Although hydrated salts are suggested to exist on RSL at a few locations [6], identification of salt compositions is still challenging. Additionally, there are no reports on detection of hydrated salts at most of the RSL sites across Mars.

In the present study, we investigate the conditions of identification of hydrated salt compositions on RSL using Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) onboarded on Mars Reconnaissance Orbiter (MRO). We calculate synthesized spectra of mixtures of basaltic soil and various hydrated salts (such as $MgCl_2 \cdot 2H_2O$) with the different mixing ratios using a linear combination method and an addition of random noise with a Gaussian distribution. We evaluate the threshold mixing ratios of salt for the identification of the salt compositions based on the analyses of the synthesized spectra. Our results show that if the mixing ratio of hydrated salt exceeds 20% in volume, O-H bands attributed from hydrated salts can be detected with CRISM. We discuss the observational conditions, such as the observational altitude from the surface, for the identification of salt compositions on RSL in future missions.

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Keywords: Mars, CRISM, salt

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Frequency of ice sheet growth recorded on Mons Pavonis, Mars

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On present-day Mars, large scale ice bodies are only found at each pole. However, in mid latitudinal areas, LDA (lobate debris apron), LVF (lineated valley fill), CCF (concentric crater fill) are reported and interpreted to have a glacial origin (Levy et al., 2014). Also, inequatorial areas, fan-shaped deposits at northwestern rim of three shield volcanos in Tharsis region though to have a glacial origin (e.g. Fastook et al., 2008).
Fan-shaped deposits sit beside three Tharsis montes and have characteristic geomorphologies extending for roughly 100-500 km from the foot of mountain, typically consisting of three facies: Smooth facies at the top, Knobby facies at the middle, and Ridged facies at the rim. Smooth facies are smooth-surfaced mounds which superpose on other facies, Knobby facies are collective hillocks a few hundred meters in radius, and Ridged facies are linear ridges (moraine-like features) parallel to the rim of the fan. At Arsia (Kadish et al., 2014) and Pavonis (Shean et al., 2005) Mons, ridged facies are especialy well-developed - containing tens to few hundreds of ridges interpreted to be moraines that indicates the varying extent of a former ice sheet. Such geomorphologies potentially record the advance and retreat of ice sheet for tens of kilometers during the Amazonian adjacent to Arsia and Pavonis Mons.
The association of these geomorphologic features to glacial processes is supported by global climate simulations of Mars during high-obliquity (Forget, 2006). The obliquity of the rotation axis of Mars is considered not stable as on the Earth, reaching 45˚ in the past 20 Myrs (Laskar et al., 2004). Such high obliquity can cause sublimation of the polar cap, enhancing the water vapor content in the atmosphere compared to present-day Mars. By diffusion and condensation model, Mellon & Jakosky (1995) found that in the surface environment of present-day Martian obliquity (25.2˚) water ice is stable only at 40˚ latitude or higher, however, when obliquity gets higher than 32.3˚, with enough amount of atmospheric water vapor, water ice becomes stable globally. This result suggests Martian surface environment has experienced such climate condition that water ice condenses and deposits in mid and low latitudinal areas. Therefore, the existence of Martian “ice age” during Amazonian high-obliquity periods is being proposed (Head et al., 2003).
If ice sheet growth and disappearance on the flanks of Tharsis Montes are an indication of the climate change caused by orbital parameters, each of moraine-like features should correspond to a paleoclimate cycle. However, fluctuation of its spacing, scale and correlation to orbital parameter have not yet been discussed. Hence, as basic study to associate distribution of moraine-like features to extent of the ice sheet, we made DEM data from CTX imagery at the rim of fan-shaped deposits at the foot of Mons Pavonis, and using the DEM data, we measured spacing and cross-sectional area of each moraine, and conducted frequency analysis on the cross section of DEM data.
As a result, spacing of moraine-like feature appeared to fluctuate from few hundred meters to 4.5 km, showing drastic change of the density. Also, cross sectional area of moraine-like feature fluctuates up to 1.4×10^4 m^2. These fluctuations potentially record the change of frequency of events that caused accumulation and ablation of ice sheet or change of velocity of ice sheet flow. In Tharsis region, these two periodic events are assumed to affect ice sheet: global climate change caused by orbital parameter, and local volcanic activity. To prove the spacing and moraine-size are driven by global climate forcings, there should be similarities between the ridges found at Pavonis, Arsia, and a correlation to orbital parameters. Therefore, frequency analysis of cross- sectional view of the terrain is being conducted. The result will be shown in the presentation.

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Keywords: Mars, Martian climate, Tharsis region, Milankovich cycle

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Development of Life Detection Microscope (LDM) for *in situ* imaging of living cells on Mars surface

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Past trial of direct detection of life on Mars by 1970's Viking mission ended up with a negative conclusion [1]. Whereas, numbers of new finding provided by Mars exploration missions in the last decade indicate that there are good reasons to perform another life detection program. The sensitivity of the gas chromatograph mass spectrometer onboard the Viking mission was not very high, and was not able to detect the microbes 10^6 cells in 1 gram clay [2,3]. Resent observations on Mars have found the evidences of past water activities. MSL Curiosity has found the temporal increase of methane concentration in Martian atmosphere [4]. The presence of reduced sulfur compound such as pyrite in Martian soil was also detected by MSL [5]. Methane and reduced sulfur compound can be the energy source to support the growth of chemoautotrophic microbes [6]. Possible presence of liquid water at Recurring Slope Lineae has been supported by the detection of hydrated salts [7]. The presence of organic compounds of Martian origin has been reported [8]. These evidences tend to support the possible presence of living microbes near the surface of Mars.

Physical and chemical limits for terrestrial life have been major foci in astrobiology [9], and are summarized in ref. [6]. Combining the environmental factors, anywhere in the Martian environment where we can find the three components, water molecules, reducing compounds and oxidative compounds could be an environment where life can be sustained for long periods of time, if other factors such as temperature, pressure, UV and other radiations permit [6]. Among these factors, most of the factors including ionic radiation, can be endured by terrestrial extremophiles. Only UV can kill the most UV-resistant microbes within minutes. However, UV can be shielded by a few centimeters soil layer. These evaluations lead to the conclusion that the Martian soil under a few cm can be the place to support the growth of microbes, if the water activity is higher than 0.6.

For exploring extant life on Mars, we have proposed to search cells from a depth of about 5 - 10 cm below the surface by the Life Detection Microscope (LDM) [6, 10]. LDM has the potential to detect single cells in the resolution of 1 micrometer and could detect less than 10^4 cells in 1 gram clay, which is much higher sensitivity than the instrument onboard Viking. We have developed the solution and combination of fluorescence pigments to detect organic compounds, and to differentiate organic compounds surrounded by membrane, which we think to be the most fundamental features that a cell should possess to constitute life. Our investigation goals are the followings. 1) Identify cell-like structure in which organic compounds are enveloped by membrane, which may represent Martian life. 2) Search for any type of organic compounds in Mars surface samples. The compounds include cells, other biological materials, and abiotic polycyclic aromatic hydrocarbon (PAH). 3) High-resolution characterization of regolith and dust particles. The current status of development of LDM will be presented.

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Keywords: fluorescent microscope, extraterrestrial life

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Development of a Mars Web-GIS for viewing multiple kinds of spectral data from orbiters

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The VIS-NIR reflectance spectra observed during latest Mars orbiter missions are of high quality and cover the whole globe. Such data sets are very informative for understanding the materials and their distribution on the surface. Each mineral has unique absorption bands in the spectra. We can identify which minerals are present by comparing the absorption bands of the observed spectra with the known absorption bands in the spectra measured in laboratories. In the case of Mars, we can estimate the type and distribution of hydrous minerals which leads to important clues to understand the water environment.

However, the VIS-NIR spectral data observed on Mars are not well utilized among the community. There are huge volume of accumulated data due to an increasing number of missions and various kinds of instruments with higher accuracy. It is not easy to process huge data and understand the relevance of them visually and intuitively.

We develop a new Mars web-GIS application, "Red Ace", to view and download the Mars observation data, especially the VIS-NIR spectra (image cube data format), easily and intuitively. The Red Ace handles multiple kinds of observation data: the Compact Reconnaissance Imaging Spectrometers for Mars (CRISM) data, the Thermal Emission Imaging System (THEMIS) data and DEM (Digital Elevation Model) data at the same time. Additionally, we use the DEM data from the Mars Orbiter Laser Altimeter (MOLA) to display 3D map of Mars with the Red Ace.

The Red Ace is developed based on CesiumJS that is an open source JavaScript library for 2D/3D maps. The user can choose the dimension of the map. In the Red Ace, the spectral observation points are displayed on the surface image layers. When the user clicks any point on the footprint of the layer, the color of the selected footprint changes and the thumbnail image appears. When the user selects any pixel on the thumbnail image, the Red Ace provides reflectance spectral data and ancillary data as graphs and tables. In response to user operation, multiple kinds of spectral data are displayed on the same window. The Red Ace also provides band- ratio images of THEMIS. The user can download band-ratio images, spectral data and ancillary data as files of PNG, CSV, JSON, XLSX and PVL formats. The user can move the windows displaying thumbnail image and graph freely. In addition, the Red Ace provides the function to control the Mars base map changing the exaggeration of height of the Mars globe. The user can change the order of layers and transparency of layers arbitrarily. The user can also jump to the region of interest directly by setting the coordinates and the zoom level. The user can handle these functions smoothly.

In the case of THEMIS, published data from the mission data archive are not reflectance data but radiance data. Therefore, the Red Ace derives reflectance data from radiance data and ancillary data, in order to compare them with CRISM spectra observed in the same spot.
In this study, considering the portability and extension of the application, the Docker was used for the development environment. Docker is an open source software platform that allow the user to develop applications quickly using containers. JSON format is adopted for data handling to make it easier to add new observation data from new observation equipments in the future. In the JSON format, it is unnecessary to associate item order and item meaning. Hence, it has high reusability and freedom. In the

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Red Ace, by standardizing the structure of JSON format data in advance, it is possible to store and handle diverse data by using the same data structure.

Keywords: Mars, Spectral data, Web-GIS

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Visualization and Analysis of the Surface of Mars with NASA's Mars Trek Portal

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Originally released in June, 2015 as a public outreach tool, Mars Trek is currently being enhanced to support site selection and analysis for upcoming human and robotic missions to Mars. Many new data products are being added, with emphasis on providing detailed information for proposed exploration zones. Data products can be loaded and even combined from many different instruments aboard many different Mars-orbiting spacecraft including Viking, Mars Global Surveyor, Mars Odyssey, Mars Reconnaissance Orbiter, and Mars Express. Users can download data products from Mars Trek and access metadata for each product. Web services and APIs allow other clients to access data from Mars Trek's servers. A standardized interface across the Trek portals provides for advanced 3D visualization and navigation. Standard keyboard gaming controls allow the user to maneuver a first-person visualization of "flying" across the surface of the Mars. User-specified bounding boxes can be used to generate STL and/or OBJ files to create physical models of surface features with 3D printers. A new VR capability allows users to generate their own virtual reality flyovers for any user-defined paths along the Mars' surface.

Mars Trek's power as a tool for education and outreach is exemplified by its being designated as key supporting infrastructure for NASA Science Mission Directorate's STEM Activation Initiative, and its serving of data to a growing community of digital planetariums.

As private industry and space agencies of a growing number of nations plan new missions to Mars, detailed maps and models of Mars' surface and climate will be essential for mission planning. Mars Trek's generalized suite of tools are being designed to meet the needs of this new generation of missions. The portal will also provide an outstanding means of dissemination of data from these missions. Layering and blending many different data products and putting individual products in the context of many others will facilitate mining of information going far beyond what individual products can provide separately. In addition to mission planning and planetary science, Mars Trek will continue supporting the essential task of engaging the public in this great adventure. Mars Trek is developed at NASA's Jet Propulsion Laboratory (JPL) and managed as a project of NASA's Solar System Exploration Research Virtual Institute (SSERVI) at NASA Ames Research Center.

At the request of the Planetary Science Division of NASA's Science Mission Directorate, we are extending the technologies of our existing Trek platforms to create a new portal for Mars' largest moon, Phobos. In this effort, we are working with the International Phobos/Deimos Landing Site Working Group and with JAXA, with JAXA's MMX mission as a primary driver.
Mars Trek is one of the portals in the NASA Solar System Treks Project (SSTP), available at https://trek.nasa.gov. NASA's Solar System Trek online portals provide web-based suites of interactive data visualization and analysis tools to enable mission planners, planetary scientists, students, and the general public to access mapped data products from past and current missions for a growing number of planetary bodies including the Moon, Mars, Vesta, etc. These portals are being used for site selection and analysis by NASA and a number of its international partners, supporting upcoming missions. In addition to demonstrating the capabilities of Mars Trek in this presentation and providing a preview of Phobos Trek,

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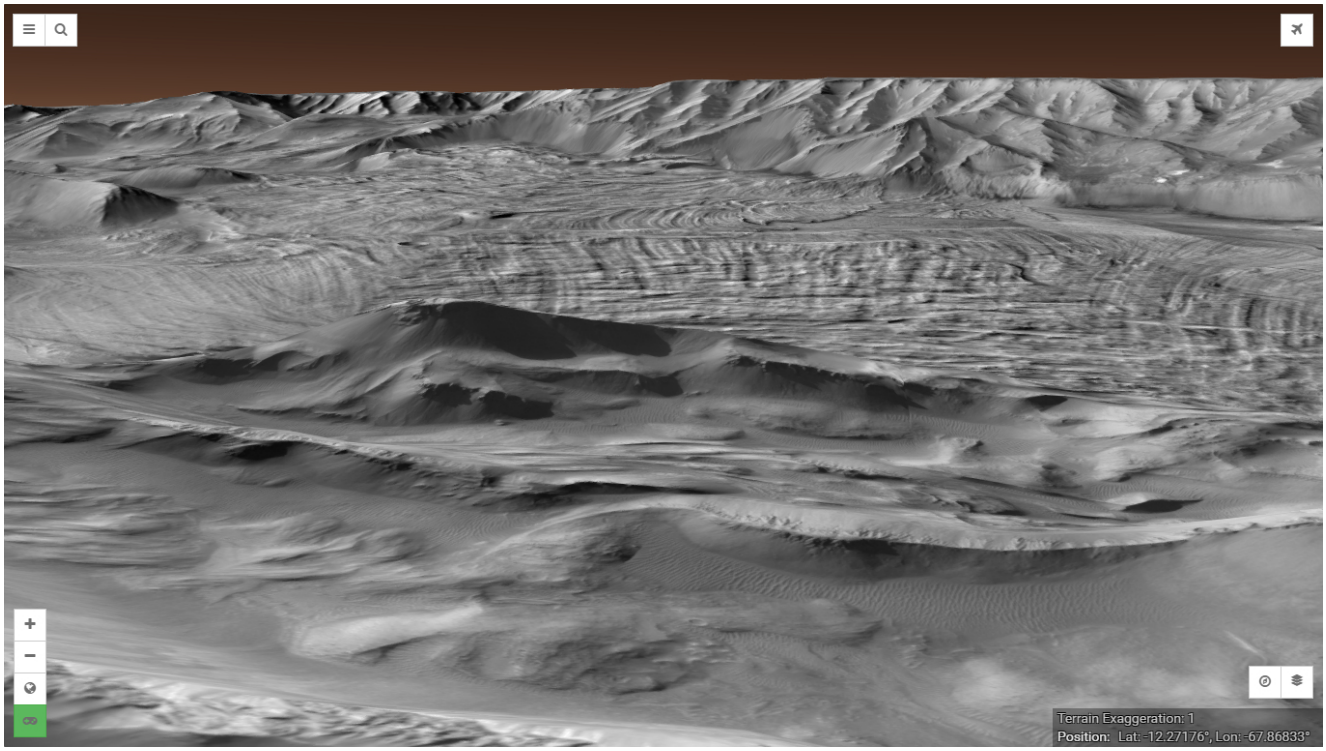
we will solicit input from the community for ideas for future enhancements to the portals.

Keywords: Mars



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Increase in Dissolved Iron Concentration from Fayalite by UltravioletA・C Irradiation

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To investigate the mystery of “Why the Mars' surface with poor oxgen has so much iron oxide" I have led student experiments at junior high schools. I will show my recent experiments and their results.
A.S.Yen (1999) showed that reactive oxygen species can also be formed on mineral grains under Martian conditions by irradiating ultraviolet C to quartz samples. Furthermore he irradiated ultraviolet C to thin iron films in the air and showed that exposure to ultraviolet radiation increases the rate of oxide formation. My experiments was irradiating ultraviolet A and C to fayalites and iron in acid water. This results indicated the possibility that iron oxides might be formed because of ultraviolet rays other than the cause of reactive oxygen species in the past.
Experiment no.1:
I had students irradiate ultraviolet rays A and C to Fayalite in hydrochloric acid.I had students irradiate ultraviolet rays A and C to Fayalite in hydrochloric acid. In this experiment, I used Fayalite from Kawamata-machi, Fukushima.
Fayalite, which is about 1g and not formatted was put in the test tube in the test tube filled with hydrochloric acid pH2.After the experiment, I had students check the concentration of iron ions in the water solution by using a digital pack test. This experiment with ultraviolet rays A was carried out 7 times and the experiment with ulttaviolet rays was carried out 3times.According to the results of the experiment with ultraviolet rays A, the quantity of iron elution increased more in the case of ultraviolet rays irradiating 6 times out of 7 than with the result of no irradiation.The results of the experiment with ultraviolet rays C were idential (3 times out of 3). The peak of wavelength ultraviolet rays A is generated by black lite is 365 nm. The peak of wavelength ultraviolet rays C is generated by germicidal lamp is 245 nm.
Experiments no.2:
I had the students irradiate ultraviolet rays A to a battery that has the iron cathode copper anode in hydrochloric acid. The Students then measured the occured voltage of the battery. I compared the voltage between ultla violet rays irradiation and non irradiation.The irradiated battery’s voltage stayed over 0.2V and the voltage did not decrease after 150hours.Another non-irradiated battery’s voltage decreased lower little by little and the voltage was close to 0V after 150 hours.This experiment was carried out 4times. In all cases the voltage of the battery that was irradiated by ultraviolet rays was higher than the non-irradiated battery.
It seems that electrons dissociate from iron atoms by ultlaviolet energy and form iron ions.
Consideration
From my experiments results, I would infer that ultraviolet rays advance the dissolution of iron ion from fayalite and iron. I think ultraviolet rays are one of the causes of iron oxide and hidroxide existing on Mars’ surface besides reactive oxygen species.It seems that there was water on Mars’ surface. There was a possibility that advancing of iron dissolution from rocks on Mars by ultraviolet rays irradiation.

Keywords: ultraviolet rays, fayalite , hydrochloric acid, iron, elution increase

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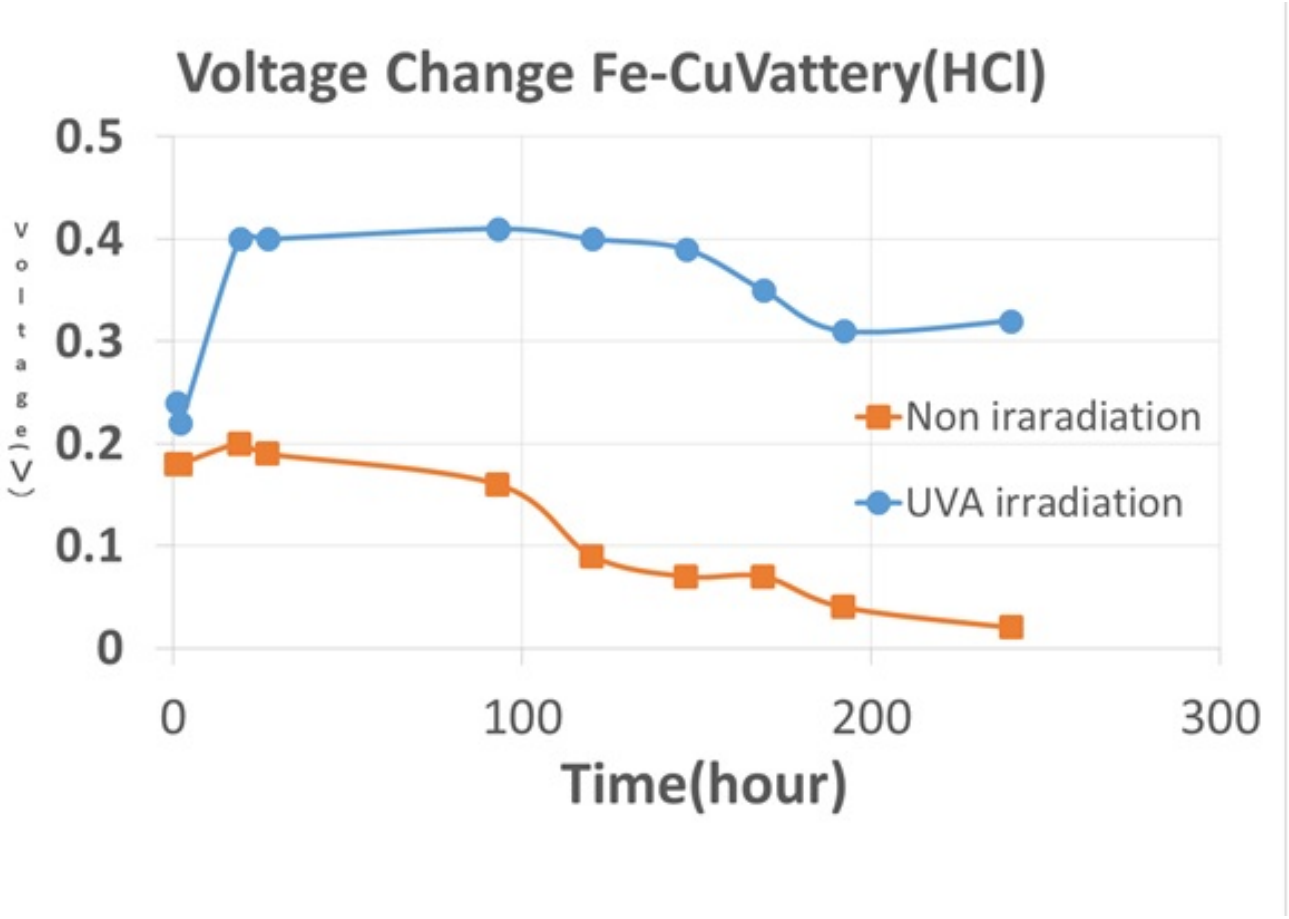

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Small-scale ridges newly identified on the equatorial region of the Phobos nearside

*Ryodo Hemmi[1], Hiroshi Kikuchi[1], Hideaki Miyamoto[1]

1. The University of Tokyo

Although the craters and grooves on Phobos are indicative of widespread and abundant surface modification during Phobos' geologic history [Basilevsky et al., 2014], little definitive evidence exists for geologically recent regolith migration other than down-slope mass-wasting [Shi et al., 2016]. Here we report newly found small-scale sinuous ridges identified in Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment (HiRISE [McEwen et al., 2007]) images of the nearside of Phobos. These ridges are spatially focused within the equatorial region (-5° to 20° N). Some of them superpose on craters and grooves, which is consistent with a geologically recent activity. They are ~200 m to ~1 km in length, several 10's m in width, and most of them are roughly parallel to each other and are generally oriented in NE-SW direction. To extract detailed topographic profiles, we constructed a high-resolution (~5-6 m/pixel; almost same as the original image) digital elevation model (DEM) by using shape-from-shading [Alexandrov and Beyer, 2018] in the selected regions of a HiRISE image and a stereo-derived HiRISE DEM (20 m/pixel) [Hemmi and Miyamoto, 2019]. Our preliminary analysis shows these ridges are less than several meters high. Their morphology and topography are unlikely to be formed by impact cratering, extensional stress fields, or mass wasting processes. In this presentation, we provide initial results of geological mapping of the small-scale ridges and discuss their possible origins.

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Keywords: Phobos, HiRISE, Digital Elevation Model

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Development of a compact Muography instrument for future Mars exploration missions

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1. University of Tokyo

Muography is a technique that uses cosmic ray muons for visualizing the interior of large-scale structures in much the same way as standard X-ray radiography is used to image the interior of smaller objects. Muography has been successfully applied to explore the internal structure of geological targets on earth. Because exploring the inner structure of the shallow subsurface of celestial bodies is important to understand their origin and evolution, we are planning to operate muography instrument in the extraterrestrial environment, especially on the surface of Mars. Applying muography to planetary explorations has some advantages over conventional internal exploration methods: (1) it is able to observe the absolute linear density of objects; (2) the passive nature of the measurements provides low power consumption; (3) the instrument size is arbitral [1]. However, in order to mount muography instrument on a spacecraft, it is essential to downsize the instrument and investigate the radiation environment on the surface of the celestial body. In this study, we designed and developed a compact muography instrument based on the knowledge of compact gamma ray detectors for nuclear medicine imaging. At the same time, we theoretically estimated the muon production on Mars and evaluated the validity of using muography instrument on Mars.

The detection device of developing muography instrument consists of 64-channel silicon photomultipliers (SiPM), plastic scintillators, dynamic Time-Over-Threshold (dTOT) boards [2], data-acquisition (DAQ) board, and high-voltage power supply units. Incident muons react with the scintillator to emit weak light, and the light is amplified by SiPM attached to the both ends of the scintillator and read out with dTOT boards. The depth of interaction (DOI) in the scintillator is analyzed by measuring the pulse-height ratio of dual-sided readout. The size of the detector is 26.2 mm×26.2 mm×31.4 mm.

We first evaluated DOI resolution of this detector using a point beta-decay source of ^{90}Sr. The result indicates that the DOI resolution (FWHM) is 7.2 mm for the emitted beta rays with a spread of 2.2 mm. Then, we performed a Geant4 [3] simulation to examine the muon angular distribution that would be detected on the ground by this instrument. The result suggests that the structure of the detector makes the observation bias (Fig. 1). There are two solutions that can be considered to solve this problem: (1) developing one more detector and analyzing the coincident signals from dual-sided readout; (2) improving DOI resolution by performing accurate calibration.

We also performed a theoretical estimation to evaluate the muon production on Mars. Although the chemical composition and the density of Martian atmosphere are different from Earth's, the known muon flux in the upper earth atmosphere can be used for estimating the muon rates on Mars [4]. The result shows that the horizontal muon flux is greater than that on Earth (Fig. 2), which means that muography is more suitable for exploration of geological targets on Mars than on Earth.

In this presentation, we report the development status of the detection device and the concrete result of numerical calculation of radiation environment on Mars.

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Keywords: Muography, Muon, Internal exploration, Mars exploration

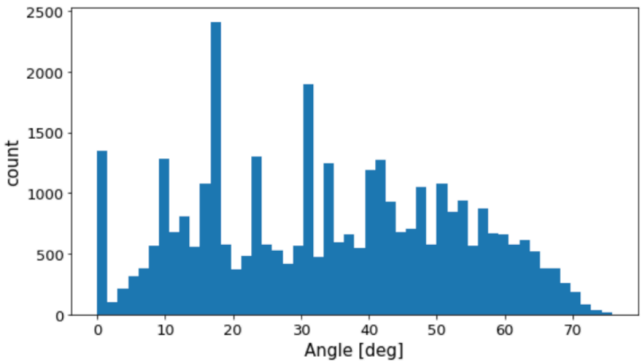

Fig. 1 The simulation result of muon zenith angular distribution that would be detected by developing instrument. The structure of detector makes the observation bias at 0°, 17° and 31°.

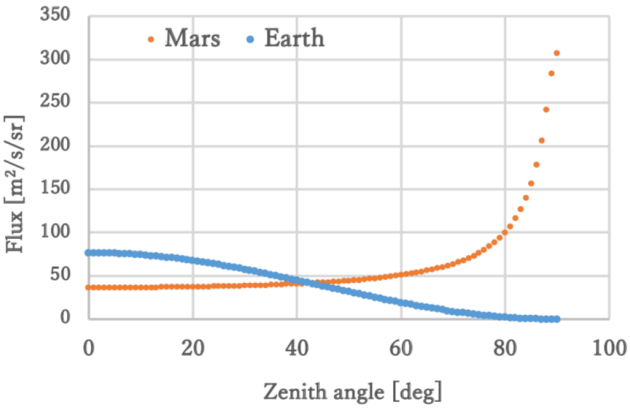

Fig. 2 Zenith angle dependence of muon flux on Mars and Earth. Horizontal muon flux on Mars is greater than that on Earth.

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[J] Oral | P (Space and Planetary Sciences)：P-PS Planetary Sciences

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | A02 TOKYO BAY MAKUHARI HALL

[P-PS07] Formation and evolution of planetary materials in the Solar System

convener:Yoko Kebukawa(Faculty of Engineering, Yokohama National University), Wataru Fujiya(Ibaraki University, College of Science), Shin Ozawa(Department of Earth Science, Graduate School of Science, Tohoku University), Megumi Matsumoto(Graduate School of Science, Tohoku University), Chairperson:Megumi Matsumoto, Wataru Fujiya

This session will focus on the evolution in the Solar System with interaction and co-evolution in minerals, water, organic matter, and noble gas in meteorites and interplanetary dust particles. New innovative analytical and theoretical techniques in various fields will be discussed. The developing methods are welcome to submit for the future mainstream of meteorite study. In order to explore the planetary materials and their evolution, both meteorite studies and experimental approaches are necessary. In this session, we will discuss these topics from extraterrestrial sample analyses and experimental works. Research works on undifferentiated and differentiated meteorites and parent body processes such as aqueous alteration, thermal metamorphism, shock metamorphism, volcanic activity, and core-mantle-crust differentiation are especially included in this session.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PPS07-01] Investigation of sugars in meteorites

★Invited Papers

*Yoshihiro Furukawa[1], Yoshito Chikaraishi[2], Naohiko Ohkouchi[3], Nanako O. Ogawa[3], Tomoki Nakamura[1] (1.Graduate School of Science, Tohoku University, 2.Institute of Low Temperature Science, Hokkaido University, 3.JAMSTEC)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PPS07-02] Establishment of ice sublimation method for detection of soluble organic matter contained in Antarctic micrometeorites in Antarctic glacier ice

*Yui Ishikawa[1], Yamamoto Kota[1], Hiroshi Naraoka[2], Toru Yada[3], Tatsuaki Okada[1,3] (1.Graduate School of Science, The University of Tokyo, 2.Graduate School of Science, Kyushu University, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PPS07-03] Magnesium-containing organic compounds in the Tagish Lake and Murchison meteorites.

*Minako Hashiguchi[1], Hiroshi Naraoka[2,1] (1.Research Center for Planetary Trace Organic Compounds, Kyushu University, 2.Department of Earth and Planetary Sciences, Kyushu University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PPS07-04] Interactions between minerals and organic materials on thermal processes in meteorite parent bodies

*Naoki Hirakawa[1], Yoko Kebukawa[1], Kensei Kobayashi[1] (1.Yokohama National University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PPS07-05] Organic matter in carbonaceous chondrite lithologies of Almahata Sitta meteorite, a polymict ureilite

*Yoko Kebukawa[1], Michael Zolensky[2], Cyrena Anne Goodrich[3], Motoo Ito[4], Nanako O. Ogawa[5], Yoshinori Takano[5], Naohiko Ohkouchi[5], Hiroki Suga[9], Matthew Marcus[6], David Kilcoyne[6], Takuji Ohigashi[7], Zia Rahman[2], Muawia H. Shaddad[8], Kensei Kobayashi[1] (1.Yokohama National University, 2.NASA Johnson Space Center, 3.Lunar and Planetary Institute, 4.Kochi Institute for Core Sample Research JAMSTEC, 5.Japan Agency for Marine-Earth Science and Technology, 6.Lawrence Berkeley National Laboratory, 7.Institute for Molecular Science, 8.University of Khartoum, 9.The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PPS07-06] Thermal Evolution of Hydrous Minerals on Small Bodies: To Understand Thermal Histories of Ryugu and Bennu

*Kana Ishimaru[1], Shogo Tachibana[2] (1.University of Tokyo, 2.UTokyo Organization for Planetary and Space Science, University of Tokyo)

Investigation of sugars in meteorites

*Yoshihiro Furukawa[1], Yoshito Chikaraishi[2], Naohiko Ohkouchi[3], Nanako O. Ogawa[3], Tomoki Nakamura[1]

1. Graduate School of Science, Tohoku University, 2. Institute of Low Temperature Science, Hokkaido University, 3. JAMSTEC

Sugars are essential components of DNA and RNA and also are essential substrates of glycolysis. Ribose is especially an important sugar as the sole component in RNA that supports both genotype and phenotype of primordial life. Investigations of sugars in meteorites have been conducted since more than 50 years ago. However, no extraterrestrial sugar that composes life has been found from any astronomical samples including meteorites, although several sugar-related compounds have been detected from meteorites. This would be preliminary because of the low concentration, difficulty in extraction, and the absence of suitable derivatization for gas chromatographic separation. Therefore, we developed a protocol to extract and analyze sugars in meteorites. We have also investigated the compound-specific carbon isotope ratios ($\delta^{13}C$ values) of sugars. All meteorites have some possibilities of biological contamination, since they have been collected on the terrestrial environment filled with biota. Thus, the evaluation of the source of sugars in meteorites (i.e., biological or extraterrestrial) is significantly important. Biological sugars are all have negative $\delta^{13}C$ values (against VPDB). Conversely, soluble organic compounds in meteorites like amino acids, nucleobases, amines, and sugar-related compounds all have positive carbon $\delta^{13}C$ values. Thus, the isotope ratios are an essential indicator for the evaluation of the origin of sugars in meteorites. In this presentation, we show the results of identification and carbon isotope ratio analysis of sugars for two CR2 chondrites. We also report the mineral composition, and chemical state of C in insoluble organic matter in these meteorites.

Keywords: ribose, sugar, meteorites

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Establishment of ice sublimation method for detection of soluble organic matter contained in Antarctic micrometeorites in Antarctic glacier ice

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1. Graduate School of Science, The University of Tokyo, 2. Graduate School of Science, Kyushu University, 3. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency

Earth is habitable even in the inner planetary region where volatiles are depleted, so that there should be sources and mechanism to supply them to earth. It has been revealed by the recent exploration of outer planets and comets that volatile components such as water and organics exist abundantly in the outer planetary region, where it is colder than in the inner planetary region. According to the researches, the existence of organic matter cannot be ignored for understanding the nature of small bodies in the outer planetary region (e.g., bodies in Edgeworth Kuiper Belt bodies or Oort Cloud). As means to get samples of that region not in the space but on the Earth, there are Antarctic MicroMeteorites (AMMs) [1]. There are interplanetary dust particles (IDPs) drifting in the interplanetary space, ejected from small solar system bodies such as asteroids and comets. Those dusts are called micrometeorites when they fall to the earth, and they are called AMMs especially when they fall to the Antarctic ice sheets. The size of MMs is defined as less than 2 mm. The accretion rate of MMs reaching the Earth’ s surface has been estimated tens of thousand tons in the previous study, which is about ten times as much as the annual influx of meteorites to the Earth [2]. Since soluble organic matter (SOM) and insoluble organic matter (IOM) are present in the MMs, it is considered that MMs rather than meteorites dominantly contributed to the supply of volatile components to the inner planetary region where they were deficient [3].

In order to understand chemical characteristics of organics in IDPs, we are aiming for the detection of SOM in AMMs. While it is difficult to determine the structure of IOM because they are Kerogen-like macromolecules, the structure of SOM can be determined. Therefore, it can be the key of elucidating the evolution of materials (chemical reaction) in the low temperature environment of the outer solar system specifically. In the previous study, samples were collected by filtering the melted water, so that no molecular species were evidently identified to have originated from primitive MMs [4, 5]. In this study, ice blocks that were collected from an ice sheet in Antarctica were sublimated as it was in order to prevent the leakage of SOM during sample collection. The apparatus for sublimation of ice blocks consists of a vacuum chamber with a sample holding jig and a dish for collecting sublimation residue set in the climate chamber. In order to prevent the ice blocks from melting before it is enough evacuated, the temperature in the climate chamber was set at -10.0 degrees Celsius. The whole apparatus was set and cooled in advance in the climate chamber. After ice blocks were set on the jig in the vacuum chamber, evacuation was started. In order to increase the efficiency of sublimation, the temperature in the climate chamber was set at 40.0 degrees Celsius after the pressure in the chamber reaching about 80 Pa.

About 330 g of Antarctica ice blocks were sublimated experimentally using the above apparatus. The residue was observed with a stereoscopic microscope. Most of the residue was occupied with white aggregated particles. According to the part of the observation by SEM-EDS, it was found that they are composed of Na, Cl, Ca, C, O and other elements. Their chemical compositions indicate that they should be marine or continental aerosols [6]. Particles composed of silicate minerals containing Mg and Fe were also found in the residue. The composition of them is consistent with that of AMMs [7]. However, it needs

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to be confirmed whether it is AMM by analytical methods such as μ-FTIR, μ-Raman, DESI-Orbitrap MAS and so on. We are planning to analyze samples in various ways, mainly on the degree of polymerization of insoluble organic matter and identification of soluble organic matter.

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Magnesium-containing organic compounds in the Tagish Lake and Murchison meteorites.

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Introduction: Recent compound analyses using high-resolution mass spectrometry (HRMS) from the solvent extracts of the Murchison meteorite (CM2) reported various CHO, CHNO, CHOS and CHNOS compounds [Schmitt-Kopplin *et al.*, 2010] and ~600 alkylated homologues of CHN compounds [Naraoka *et al.*, 2017]. CHOMg compounds were also identified from methanol extracts of various meteorites by using HRMS [Ruf *et al.*, 2017]. To understand chemical evolution of the meteoritic organic matter, investigation of their relationship with surrounding minerals by *in-situ* analysis is necessary. Our previous studies revealed spatial distribution of alkylated homologues of CHN compounds in the Murray and Murchison meteorites using desorption electrospray ionization (DESI) with HRMS [Naraoka and Hashiguchi, 2018; Hashiguchi and Naraoka, 2019], but clear relationship with specific minerals was not found. In this study, we carried out DESI-HRMS imaging on the Tagish Lake meteorite to reveal the relationship between SOM and minerals.

Experimental: Fragments of the Tagish Lake (Ung-C2) meteorite and the Murchison meteorite with a flat surface of each meteorite were embedded in indium or alloy with low melting point (60 ºC). The DESI-HRMS imaging was performed using a 2D DESI ion source equipped with Orbitrap MS. A spray solvent was methanol 100% with the flow rate of 2–3 μL/min, and electrospray voltage was set at 3 kV. The positive ions (m/z 60–500) were collected with mass resolution of 140,000 ($m/\Delta m$ at m/z 200) on the surface of Tagish Lake (2.5×2.5 mm^2) and Murchison (4.5×4.5 mm^2). Antigorite grains was also analyzed to understand adsorption effects of organic compounds on clay minerals during storage in a clean room (Class 1000). After the imaging, FE-SEM-EDS analysis was carried out on the samples without coating and polishing.

Results and Discussion: Any CHN compounds were not detected from the Tagish Lake by DESI-HRMS imaging, whereas several alkylated homologues of CHN compounds were identified from Murchison similar to the previous study [Hashiguchi and Naraoka et al., 2019]. The distinctly different organic characteristics between the two meteorites was contrast to previous bulk analysis showing its quite low abundance of CHN compounds in Tagish Lake relative to Murchison [e.g. Pizzarello *et al.*, 2006]. Instead of the CHN compounds, abundant Mg-containing organic compounds were identified from Tagish Lake with mass precision of <1.5 ppm. Isotopomers of $^{24\text{-}26}$Mg for compounds were identified using the exact mass and Mg isotope simulation. Several families of $C_nH_mO_xMg^+$ (n=0-10) different from the compounds identified by Ruf *et al.* (2017), and $C_nH_mN_yO_xMg^+$ (n=1-7) were assigned using Kendrick mass defect plots. The Mg-organic compounds were also detected from Murchison, however, the abundance was more than an order of magnitude lower than that in Tagish Lake. By DESI-HRMS analysis on antigorite grains, some Mg-organic compounds (e.g. $C_nH_{2n+2}NO_2Mg^+$ families) showed high ion intensity after storage for 1 month, indicating their adsorption effects on the clay minerals. In contrast, other Mg-organic compounds were not found by the adsorption effect, suggesting that these compounds were indigenous in the meteorites.

The CHOMg and CHNOMg compounds showed a similar spatial distribution with various intensity among the different families in both meteorites. In the Tagish Lake meteorite, they were likely to be concentrated in the matrix with less framboidal magnetite and relatively saponite/serpentine-rich region. This indicates that the Mg-organic compounds might have been formed by ion exchange between organic species and

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the clay minerals during aqueous alteration. Moreover, the Mg-organic compounds and CHN compounds were also distributed in matrix of Murchison, however, their spatial distributions were different, suggesting different origins between these compounds.

Keywords: Primitive meteorites, Magnesium containing organic compounds, Molecular imaging

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Interactions between minerals and organic materials on thermal processes in meteorite parent bodies

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Introduction:
Carbonaceous chondrites and several other chondrites contain a few wt.% of organic matters. Pearson et al. (2002) reported co-existence of organic matters with phyllosilicates in the matrix or chondrule rim and discussed the roles of phyllosilicates on alteration of organic matters during aqueous processing in a meteorite parent body. However, interaction between minerals and organics has not been well-known compared to interactions between minerals and water or organics and water. In this study, molecular cloud organic material analogue (Kouchi et al, 2002; hereafter called MC) was heated with powdered minerals using an autoclave to understand, 1) the effect of minerals on thermal metamorphism of organic matter, 2) whether minerals were affected by organic matter or not.

Methods:
MC was prepared by mixing chemical compounds based on Kouchi et al. (2002). Samples used in this study were MC (5 g), MC (0.25 g) with olivine (0.25 g), and MC (0.25 g) + montmorillonite (0.25 g). Each sample was put in a pyrex glass tube without sealing and the tube was placed in the autoclave. The autoclave was purged with N2+H2 gas mixture (99 : 1, v/v). The samples were heated at 200 ˚C, 300 ˚C, and 400 ˚C in the autoclave for 5 hours under 1 atm. After cooling to room temperature, recovered samples were analyzed using FT-IR, GC/MS, XRD and SEM-EDS.

Results and Discussion:
MC heated products: Changes of the peak position and the intensity of carbonyl C=O in IR spectra with temperatures were consistent with the products at each temperature detected by GC/MS. The long-chain carboxylic acids in the initial MC were converted into long-chain ester compounds at 200 ˚C. Long-chain ester, amide and nitrile compounds were produced at 300 ˚C, and long-chain alkane and nitrile compounds were produced at 400 ˚C. Dehydration condensation of carboxylic acids with alcohols and amines in the initial MC formed esters and amides, respectively, at 200 ˚C and 300 ˚C. Alkanes and nitriles were formed at 400 ˚C through thermal cracking of long chain aliphatic compounds and dehydration of amides, respectively.

Monoaromatic hydrocarbons also increased at 400 ˚C. Monoaromatic hydrocarbons were probably formed through thermal cracking of bridged aromatic hydrocarbons (e.g.,
4,4’ -methylenebis-(2,6-dimethylphenol)) in the initial MC at 400 ˚C.

Effects of minerals: Changes in the peak position of carbonyl C=O was more significant with montmorillonite than with olivine. Carbonyl C=O significantly decreased at 300 ˚C and 400 ˚C with montmorillonite. This result could be explained by the differences of acidity and contact surface area of olivine and montmorillonite.

Alexander et al. (2007) reported that both O/C ratios and H/C ratios of insoluble organic matter (IOM) in heated CM chondrites and ordinary chondrites decreased by heating. However, O/C ratios of IOM in heated CM chondrites were much lower than these in ordinary chondrites when compared at the same

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H/C ranges. It may indicate that pyrolysis of IOM in heated CM chondrites was promoted by co-existed phyllosilicates even at lower degree of thermal processes compared to IOM in ordinary chondrites which contain large amount of olivine but less phyllosilicates.

Alteration of minerals: Possibility of partial hydrous alteration in olivine to serpentine was found in products at 200 ˚C and 300 ˚C by SEM observations, while the alteration was not detected at 400 ˚C. It could be due to the dehydration of MC that hydrates olivine at 200 ˚C and 300 ˚C. This result might indicate that hydrated minerals could have formed without water but with organics in some meteorite parent bodies accreted inside the snow line. Further analysis using TEM is now being conducted to confirm the formation of phyllosilicates on the surface of olivine particles reacted with MC.

Keywords: pyrolysis of organic matter, meteorite parent body, phyllosilicate

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Organic matter in carbonaceous chondrite lithologies of Almahata Sitta meteorite, a polymict ureilite

*Yoko Kebukawa[1], Michael Zolensky[2], Cyrena Anne Goodrich[3], Motoo Ito[4], Nanako O. Ogawa[5], Yoshinori Takano[5], Naohiko Ohkouchi[5], Hiroki Suga[9], Matthew Marcus[6], David Kilcoyne[6], Takuji Ohigashi[7], Zia Rahman[2], Muawia H. Shaddad[8], Kensei Kobayashi[1]

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The Almahata Sitta (AhS) meteorite is a brecciated, polymict ureilite that has originated from the near-earth asteroid 2008 TC3 which is classified as an F-type asteroid (a group in C complex) in spectroscopic taxonomy [1]. Carbonaceous chondritic lithologies AhS 671 and 91/91A have been characterized and contain phyllosilicates, bruennerite, dolomite, magnetite, fayalite, ilmenite, phosphates, pyrrhotite, and pentlandite [2]. These lithologies are breccias and enclose fragments of ureilitic olivine and pyroxene [2]. We investigated organic matter (OM) in AhS 671 and 91A with various methods including C and N elemental and isotopic analysis and FTIR for bulk samples (~100 μg), and microscopic analysis of their FIB sections using STXM/C-XANES and NanoSIMS.

AhS 671

The IR absorption spectrum of AhS 671 show phyllosilicates and carbonates consistent with mineralogical observations [2], and similar to the IR spectra of CI chondrites [3]. AhS 671 contains 3.9 ±0.22 wt.% of C and 0.19 ±0.02 wt.% of N with δ^{13}C = -3.8 ±0.7 ‰and δ^{15}N = 50.5 ±2.6 ‰. Its δ^{15}N and N/C ratio (0.042 ±0.002, atomic) is close to the values of insoluble organic matter (IOM) in the Tagish Lake meteorite [4]. Note that the N/C ratio of OM in AhS 671 would be higher than the value of the bulk sample since the bulk value includes carbonates.

C-XANES spectra of the organic-rich regions in the AhS 671 FIB section show large peaks at 285 eV assigned to aromatic carbon with no other specific features. Although, organic matter in AS 671 is highly aromatic, there is no 1s-σ^* exciton peak at 291.7 eV of graphene structures that is characteristic of thermally-metamorphosed meteorites [5]. Such characteristics are similar to the C-rich aggregate in the Zag clast [6]. The difference of their organic matter is related to morphology; Zag organics form large (over 10 μm) aggregates while those in AhS 671 are smaller and mixed with the matrix at the submicron scale. δ^{13}C and δ^{15}N obtained with NanoSIMS in C-rich areas are homogeneous with averages of 3 ±3 ‰ and 234 ±32 ‰, respectively. The δ^{15}N is higher than the bulk value and is close to the value of IOM of CR chondrites [7]. The δD value in C-rich areas is 988 ±59 ‰. It is similar to the value of IOM of CI and CM chondrites [7], but less than the value of CRs [7]. The N isotopes of organic matter in AhS 671 shows an isotopically heavier than ureilitic fragments of AhS (-53 to -94 ‰[8]) and rather close to the values of primitive carbonaceous chondrites. However, OM is dominated in aromatic structure without any sign of graphitization.

AhS 91A

Not like AhS 671, the IR absorption spectrum of AhS 91A show no sighs if phyllosilicates and carbonates. The C and N contents vary up to 4.8 wt.% and 0.056 wt.%, respectively, with the average δ^{13}C of -17 ±8

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‰. It is consistent with the heterogeneous nature of AhS 91A. We could not obtain C-XANES due to low C contents in the FIB section of AhS 91A. We are going to analyze an additional FIB section since AhS 91A is highly heterogeneous.

Considering the molecular structure and the nitrogen isotope composition, the organic matter in AhS 671 is similar origin to the C-rich aggregate in the Zag clast [6], and thus perhaps related to D/P asteroids.

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Thermal Evolution of Hydrous Minerals on Small Bodies: To Understand Thermal Histories of Ryugu and Bennu

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Asteroid sample return missions JAXA's Hayabusa2 and NASA's OSIRIS-REx are currently exploring asteroids Ryugu and Bennu, respectively. Infrared spectroscopic observation done by the near-infrared spectrometer on board Hayabusa2 (NIRS3) suggests that Ryugu has a weak absorption feature of hydrous minerals, while the visible and infrared spectrometer on board OSIRIS-REx (OVIRS) have detected a clear absorption feature of hydrous minerals on the surface of Bennu. These findings indicate that two asteroids experienced different thermal histories, and dehydration of hydrous phases could have occurred more effectively on Ryugu. It is thus important to understand thermal transformation processes of hydrous minerals, but there has been limited kinetic data that can be extrapolated to the processes occurring in the geologic timescale. Therefore, with the aim of understanding thermal metamorphism on Ryugu/Bennu, we conducted heating experiments of serpentine in vacuum.

The starting material of serpentine was ground into powder using an agate mortar and pestle to a particle size of ~1 μm. Samples were heated at 500 - 800˚C, for durations of 2 –88 hours in vacuum (10^{-4} –10^{-5} Pa). The analyses were done with XRD (X-ray powder diffraction) at the University of Tokyo and FTIR (Fourier transform infrared spectroscopy) at Hokkaido University. The weight changes of the samples were obtained by weighing them before and after the experiments using an electric balance.

The serpentine samples heated at 500˚C were dehydrated with heating, but crystalline serpentine was still dominant in the run products. The samples heated at 600˚C decomposed to become amorphous. The XRD spectra of the samples heated at 650℃ show the presence of small and broad peaks of olivine that recrystallized from the amorphous and also a slight halo representing remaining amorphous. The samples heated at 700˚C also have small and broad XRD peaks of olivine without the halo feature of amorphous silicate. The XRD spectra of the samples heated at 800˚C show the strongest peak of enstatite in addition to the peaks of olivine. FTIR spectra also confirm the above observations.

The FTIR spectra of the samples heated at 650˚C and 700˚C were analyzed further to obtain the kinetics of crystallization of olivine from dehydrated serpentine. The absorbance ratio of the peaks at 10.4 and 11.4 mm, both of which are characteristic of olivine, was converted into the degree of olivine crystallization based on the results by [1]. The time evolution of crystallization degree at 650 and 700˚C were fitted by the Johnson-Mehl-Avrami-Kolmogorov equation with the Avrami exponent of 1.5 [1], and the crystallization rate constant k [$h^{-1.5}$] of 0.032 and 0.34 were obtained at 650 and 700˚C, respectively. The estimated activation energy for the crystallization is 356 kJ mol^{-1}.

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The TTT (time-temperature-transformation) diagrams for dehydration and recrystallization of serpentine were obtained. The dehydration timescale was adopted from [2]. Considering that the decay of ^{26}Al with a half-life of 0.72 My is a possible heat source within parent bodies of Ryugu and Bennu in the early Solar System, the heating time scale should be shorter than 10 Myr. The diagram indicates that Bennu, with a clear infrared feature of hydrous minerals should not have experienced heating at >350 K on its parent body. Ryugu, with a subtle feature of hydrous minerals may have been heated at >450 K on its parent body. Fujiya et al. (2012) [3] estimated that within a 60-km sized asteroid accreted 3.5 Myr after the Solar System formation, the highest temperature is about 400 –450 K that lasts for 2 –3 Myr at 3 km distance from the center. If this is the case, most part of the asteroid was kept below 350 K, which could be similar to Bennu. In order to dehydrate Ryugu, its parent body may have been larger than 60 km in diameter or may have accreted earlier than 3.5 Myr after the Solar System formation with a more available heat source (^{26}Al).

References: [1] Yamamoto D. and Tachibana S. (2018) ACS Earth Space Chem. 2, 778–786. [2] Yamamoto D. (2016) Master thesis. [3] Fujiya W. et al. (2012) Nat. Commun. 3, 627(6 pp).

Keywords: thermal metamorphism, asteroid

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[E] Poster | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_2

[P-EM14] Recent Advances in Ionosphere Observation and Modeling for Monitoring and Forecast

convener:Yang-Yi Sun(China University of Geosciences), CHIYEN LIN(Center for Astronautical Physics and Engineering, National Central University, TAIWAN), MINYANG CHOU(National Cheng Kung University)

Over the past few decades, rapid developments in space technology have advanced the research of ionospheric space weather by increasing a great number of ground- and space-based observations. In the ground segment, the dense ground-based GNSS networks, radars, and airglow instruments have greatly extended the observational coverages. In the space segment, the extraordinary satellite missions with payloads onboard the satellites providing radio occultation soundings of vertical electron density structure and in-situ observations of airglow, temperature, neutral winds, and electron density contribute to the understanding of middle and upper atmospheric dynamics. With the large amount and diversity of datasets, theoretical and empirical models can be validated and implemented for inclusion of new thermosphere and ionosphere phenomena. Furthermore, remarkable breakthrough of data assimilation techniques advances the ionosphere monitoring and forecast. The recent innovations in observations and models reinterpret the studies of ionospheric space weather. The purpose of this session is to solicit studies providing observations, theoretical and empirical modeling and data assimilation on the multiple scales of ionospheric phenomena, from global morphology to small-scale irregularities and traveling ionospheric disturbances. Studies on magnetically quiescent and disturbed conditions will be both addressed.

[PEM14-P01] The Daytime and Nighttime Mapped Whistler Plasmapause Observed by DEMETER

*ChaoYen Chen[1,2], Tiger J. Y. Liu[1,2,3] (1.Institute of Space Science, National Central University, Taiwan, 2.Center for Astronautical Physics and Engineering, National Central University, Taiwan , 3.Center for Space and Remote Sensing Research, National Central University, Taiwan)

[PEM14-P02] Global Plasma Density Irregularity Distributions Observed by Advanced Ionospheric Probe Onboard FORMOSAT-5 Satellite

*Chi-Kuang Chao[1], Yi-Wun Chen[1] (1.Graduate Institute of Space Science, National Central University)

[PEM14-P03] The First Result on Ionospheric Space Weather of FORMOSAT-5/AIP Ion Density

*FU-YUAN CHANG[1], JANN-YENQ Liu[1], Chi-Kuang Chao[1] (1.National Central University)

[PEM14-P04] The global total electron content reconstruction in the local time frame

*Tsung-Che Tsai[1,2], Hau-Kun Jhuang[3], Lou-Chuang Lee[3,4,5], Yi-Ying Ho[4] (1.National Center for High-Performance Computing, National Applied Research Laboratories, Hsinchu, Taiwan, 2.Department of Civil Engineering, National Chiao Tung University, Hsinchu, Taiwan., 3.Department of Geoscience, National Taiwan University, Taipei, Taiwan., 4.Institute of Earth Science, Academia Sinica, Nankang, Taipei, Taiwan., 5.Institute of Space Science, National Central University, Jhongli, Taiwan.)

[PEM14-P05] Research on impacts of power line harmonic radiation on ionospheric parameters

*Qiang Guo[1], Jing Wu[1], Ling Yang[1] (1.Beihang University)

[PEM14-P06] Analysis of cosmic rays dynamics and ionospheric parameters during increased solar activity and magnetic storms

*Oksana Mandrikova[1], Yurii Polozov[1], Bogdana Mandrikova[1,2] (1.Institute of Cosmophysical Research and Radio Wave Propagation, Far Eastern Branch of the Russian Academy of Sciences, 2.Saint Petersburg

Electrotechnical University "LETI")

[PEM14-P07] King Tidal Effects on the ionosphere during the period of 2000 to 2017

*TsungYu Wu[1], JANN-YENQ Liu[1] (1.Institute of Space Science, NCU, Taiwan)

[PEM14-P08] SuperDARN near range echoes and higher resolution measurement - recent improvement and future

*Akira Sessai Yukimatu[1,2] (1.National Institute of Polar Research, 2.SOKENDAI)

[PEM14-P09] **The ionospheric wave peak structures in the low latitude region and their seasonal, and solar activity dependence based on Global Ionosphere Maps**

*Hau-Kun Jhuang[1], Tsung-Che Tsai[2,3], Lou-Chuang Lee[1,4,5], Yi-Ying Ho[4] (1.Department of Geosciences, National Taiwan University, Taipei, Taiwan, 2.National Center for High-performance Computing, National Applied Research Laboratories, Hsinchu, Taiwan, 3.Department of Civil Engineering, National Chiao Tung University, Hsinchu, Taiwan, 4.Institute of Earth Science, Academia Sinica, Nankang, Taipei, Taiwan, 5.Institute of Space Science, National Central University, Jhongli, Taiwan)

The Daytime and Nighttime Mapped Whistler Plasmapause Observed by DEMETER

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This paper investigates the plasmapause positions in the ionosphere by measurement of the whistler count probed by DEMETER (Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions) satellite in the daytime at 1030 LT (local time) and the nighttime at 2230 LT during 2005-2010. The whistler finds the plasmapause position which can be clearly allocated in both daytime and nighttime. We examine the nighttime/daytime plasmapause in various longitudes, solar activities, seasons, and geomagnetic actives. Results show that the daytime plasmapause appears in the equatorward side of the nighttime one. Both the daytime and nighttime plasmapause are sensitive to solar activity, which move equatorward form the low to high solar activity in the study period. The seasonal variation of the plasmapause are rather random and insignificant. During magnetic disturbed condition, the plasmapause tend to move equatorward.

Keywords: Plasmapause position, Whistler, DEMETER satellite

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Global Plasma Density Irregularity Distributions Observed by Advanced Ionospheric Probe Onboard FORMOSAT-5 Satellite

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A FORMOSAT-5 satellite has been launched on25 August 2017 CST into a 98.28° inclination sun-synchronous circular orbit at 720 km altitude along the 1030/2230 local time sectors. The orbital coverage provides a great opportunity to survey terrestrial ionosphere from equatorial to polar region every two days. Advanced Ionospheric Probe (AIP) is a piggyback science payload developed by National Central University for the FORMOSAT-5 satellite to measure ionospheric plasma concentrations, velocities, and temperatures. It is also capable of measuring ionospheric plasma density irregularities at a sample rate up to 8,192 Hz over a wide range of spatial scales. In this presentation/poster, distributions and structures of pre-midnight low-latitude ionospheric plasma density irregularities will be shown from AIP science data collected since winter 2017. Especially, seasonal variations of the distributions will be compared with ROCSAT-1/Ionospheric Plasma and Electrodynamics Instrument dataset (1999-2004) to understand their trends. Meanwhile, high resolution data measured at a BURST rate (8,192 Hz) in some longitudinal sectors with high plasma density irregularity occurrence rates will also be investigated by spectral analysis to understand their characteristics.

Keywords: AIP, FORMOSAT-5, Irregularities

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The First Result on Ionospheric Space Weather of FORMOSAT-5/AIP Ion Density

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1. National Central University

The science payload of Advantage Ionosphere Probe (AIP) onboard FORMOSAT-5 (F5) launched on 24 August 2017 has being operated in a Sun synchronous orbit at 720km altitude with an inclination angle of 98.28 degrees and the revisit period every 2-day. The global distribution of F5/AIP ion density (Ni) in nighttime of 2200LT during November 2017-October 2018 is examined and reported. F5/AIP ion densities show that equatorial plasma depletions frequently appear over South America, Africa, and Asia sectors; four-peaked EIA (non-migrating tide) structures prominently occur in September-March; and plasma depletion bays (PDBs) at low-latitudes in April-August. It is found that prominent locations of the plasma depletions slightly differ from those of equatorial irregularities, while non-migrating tide and PDBs result from different physical mechanisms.

Keywords: topside ionosphere, equatorial plasma depletion bay, plasma drift

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The global total electron content reconstruction in the local time frame

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The total electron content (TEC) data from Global Ionosphere Maps provide a global TEC map in the region between latitude 87.5˚S to 87.5˚N, and longitude 180˚W to 180˚E. The TEC data in geographic coordinates are first transformed into geomagnetic coordinates through Altitude-Adjusted Corrected Geomagnetic Model (AACGM). We then use 2-dimensional (longitude, 180˚W~180˚E and time, 10 days) Fourier transform (FT) of TEC variations along different geomagnetic latitude to obtain all wave modes for the period from November 18, to October 15, 2014. By the summation of all non-migrating tides, migrating tides, and zonal mean, the TEC global map in the local time frame is reconstructed. Again, the AACGM is applied to transform from geomagnetic coordinates back to geographic coordinates. The local time evolution in geographic coordinates of TEC is then produced. The features of TEC peaks in the local time frame are presented.

Keywords: geomagnetic coordinates, Global Ionospheric Maps, Fourier transform, Ionospheric tides

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Research on impacts of power line harmonic radiation on ionospheric parameters

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Introduction: Power line harmonic radiation (PLHR) refers to a kind of electromagnetic wave phenomena at harmonic frequencies of 50 or 60 Hz, which are the working frequencies of terrestrial power systems. Since the 1970s, PLHR events have been detected with several magnetically conjugate pairs of receivers and different satellites [1, 2, 3]. With the increase of global power consumption, PLHR has become more serious. Already, many scientific satellites have observed such anthropogenic electromagnetic waves in the ionosphere, and some possible typical impacts of those waves on the ionosphere have been reported [4]. However, reaching a final conclusion as to the impacts has been proven to be a difficult task. To further understand PLHR and its impacts, we utilize the data of three scientific payloads of DEMETER satellite collected with the Langmuir probe (ISL), thermal plasma analyzer (IAP), and energetic particle detector (IDP) to study the variation of ionospheric parameters due to the occurrence of PLHR.

Analytical Methods: DEMETER is a French seismo-electromagnetic microsatellite that was in operation from June 29, 2004 to December 9, 2010. The ISL onboard measured the electron density (N_e), electron temperature (T_e), and ion density (N_i). The IAP measured the density of H^+ (N_{H+}), He^+ (N_{He+}), O^+ (N_{O+}), and ion temperature (T_i). The IDP measured the electron fluxes in the range from 70 keV to 2.5 MeV. The variations of ionospheric parameters are affected by many factors, including latitude, longitude, altitude, daytime or nighttime, season, and solar activity. To minimize these impacts, we proposed an approach that compares the data from the PLHR-orbit and quiet-period orbit ($AE \leqq 50$ nT, AE is an index to evaluate the level of geomagnetic activity).

Among the 133 PLHR events detected by Wu et al. [5] when DEMETER flew over China, one quiet-period orbit, covering most of China's latitudes, was found for each year (2004-2010) according to AE index. In each PLHR-orbit, three-segment dataset were obtained: 30s before, at, and 30s after the occurrence region of PLHR event. By subtracting data of quiet-period orbit with corresponding latitudes from each-segment data of PLHR-orbit, we statistically analyzed the variation trend of ionospheric parameter in each PLHR-orbit due to PLHR.

Results & Discussion: With ISL and IAP data, it was found that both N_e and T_e were at a low level, N_{H+} was at a high level, and N_{O+} was at a low level when PLHR occurred. These results were generally helpful for understanding the formation behaviors of PLHR and were consistent with the theoretical results. From the analysis of IDP data, obvious variations of pitch angles before and after PLHR were occasionally observed to occur, and the variation did not exceed 10°. Its corresponding equatorial pitch-angle may not have fallen into a loss-cone, so the variation tendency of the electron flux did not have a definite connection with the pitch angle. The statistical results indicate that when PLHR occurs, the electron flux in the high-band (>1 MeV) tends to decrease and the decremental magnitude is very large, while the electron flux in the middle-band tends to increase and the incremental magnitude is relatively large.

Reference: [1] R. A. Helliwell, et al. (1975) *J. Geophys. Res-Space Phys.*, 80, 4249-4258. [2] J. P. Matthews, et al. (1981) *Planet. Space Sci.*, 29, 97-106. [3] M. Parrot, et al. (2014) *J. Geophys. Res-Space Phys.*, 119, 5744-5754. [4] M. Parrot, et al. (1996) *Surv. Geophys.*, 17, 67-100. [5] J. Wu, et al. (2017) *J. Geophys.*

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Res-Space Phys., 122, 3448-3458.

Keywords: power line harmonic radiation, ionospheric parameters, DEMETER

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Analysis of cosmic rays dynamics and ionospheric parameters during increased solar activity and magnetic storms

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Based on the ground station data, the paper makes complex analysis of cosmic ray dynamics and of ionospheric parameters during strong and moderate magnetic storms in 2015-2018. During the investigation, new methods of modeling and data analysis were applied. A neural network model for neutron monitor data classification was presented. This model makes it possible to evaluate galactic cosmic ray flux state and to detect periods of sporadic effect occurrences in automatic mode. By the use of this model, sporadic effects preceding and accompanying strong and moderate magnetic storms were detected. The model showed its efficiency when applied for data on-line analysis and for detection of sporadic effects including those of small amplitude. Ionospheric data were analyzed on the bases of multi-component modeling method and ionospheric parameter analysis [1, 2]. It allowed us to detect ionospheric disturbances of different intensity and to estimate their characteristics. The results of the work confirmed the possibility of ionospheric electron concentration increase effect preceding magnetic storm commencements [3]. Comparison with cosmic ray data showed the correlation of the effects in the ionospehre with anomalous changes in cosmic ray dynamics that was first mentioned in the paper [3].

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Keywords: cosmic rays, ionospheric parameters, data analysis

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King Tidal Effects on the ionosphere during the period of 2000 to 2017

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1. Institute of Space Science, NCU, Taiwan

This study examines the spring tide signature of the 14.7-day period in concurrent/co-located measurements of the ionosphere total electron content (TEC) and sea level in an 18-year period of 2000-2017. A discrete Fourier transform is applied to find amplitude and phase of the spring tide in the TEC and sea level. Results show that the spring tide amplitude in the sea level is clear and steady, while that in the ionospheric TEC is rather fluctuated and proportional to the ambient TEC value. The relative amplitude of TEC in the 18-year is a function of the solar local time and become prominent in the daytime of 08:00-19:00. and however that in the nighttime 00:00-06:00 LT becomes prominent in 2002, 2005, 2009, and 2015, when the perihelion and perigee simultaneously occur. On the other hand, the phase of the spring tide signature in the sea level and TEC yield a 3-year period, which is close to the time interval of the above prominent spring tide signature in the nighttime. More detailed discussions and results will be presented.

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SuperDARN near range echoes and higher resolution measurement - recent improvement and future

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1. National Institute of Polar Research, 2. SOKENDAI

SuperDARN (Super Dual Auroral Radar Network) is an international high-frequency radar network originally intended to cover a wide range of polar ionosphere in both hemispheres by its fields-of-view and to monitor global ionospheric plasma convection in high temporal resolution of about 1-2 minitues in quasi real time mainly for space weather research. It can observe not only basic and important ionospheric plasma Doppler velocity and electric field, a variety of geomagnetic waves, ionospheric disturbances and irregularities, but also properties of neutral atmosphere, e.g., traveling ionospheric disturbances (TIDs), mesoepheric echoes like PMSEs and neutral wind around mesopause region. As it is originally designed to measure global large-scale ionospheric plasma parameters, the spatial resolution has been rather coarse, and it was originally difficult to obtain height information of echoes, high temporal resolution less than 1 second, and high spatial resolution of less than 15km in radial direction. Echo height information is very important especially to distinguish those among D, E and F regions as the properties of plasma among them are considerably different and also to obtain precise altitude of meteor echoes around mesopause due to existence of thin layers of neutral wind shear. Recent development in calibrating radar interferometry in SuperDARN community is an important step to improve much the reliability of height information especially in near range echoes and also of region identification for further echoes as well. Combining raw I/Q time series analysis method (Yukimatu and Tsutsumi, GRL, 2002) to be applied to extract underdense meteor echoes precisely, frequency domain interferometry (FDI) and/or over-sampling technique (Tsutsumi et al., 2009) with the appropriate interferometer calibration will improve the reliability and height resolution of the neutral wind measurement possibly leading to global neutral wind observing network around mesopause region with SuperDARN which will contribute to many studies on mesosphere-lower-thermosphere (MLT) or mesoephere-thermosphere-ionosphere (MTI) region dynamics and vertical coupling between ionosphere and neutral upper atmosphere. Another issue possibly critical for some specific studies, e.g., on short period electro-magnetic waves is possibility to achieve higher temporal resolution within a second as well as higher spatial resolution in range direction. (Higher spatial resolution in azimuth direction has been already tried and achieved by some radars using general imaging or spatial domain interferometry (SDI) technique.) There have been some trial against these possibilities with some success depending on the cases of the applied phenomena and the conditions of echoes, but have still been thought to be difficult to be overcome. This presentation will describe the evolution of SuperDARN near range echo measurement after last JpGU meeting, and will also discuss about the reliability of high temporal resolution measurement and the possible method to obtain reliable high temporal resolution data to extend the ability of SuperDARN.

Keywords: SuperDARN, near range echoes, electromagnetic waves, high temporal resolution

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The ionospheric wave peak structures in the low latitude region and their seasonal, and solar activity dependence based on Global Ionosphere Maps

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The total electron content (TEC) data from Global Ionosphere Maps (GIM) are used to obtain the wave modes in both UT (universal time) and LT (local time) frames through the Fourier transform. The summation of contributing wave modes at a given local time provides the longitudinal variation of the wave peak structure. The phases of wave modes lead to a constructive or destructive interference of contributing wave modes, which gives different wave peak structure at different local time. The dependence of the wave peak structures on latitudinal, seasonal, and solar activity is studied.

Keywords: Global Ionosphere Maps, Ionospheric tides, Atmosphere Ionosphere coupling

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[E] Poster | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_5

[P-EM14] Recent Advances in Ionosphere Observation and Modeling for Monitoring and Forecast

convener:Yang-Yi Sun(China University of Geosciences), CHIYEN LIN(Center for Astronautical Physics and Engineering, National Central University, TAIWAN), MINYANG CHOU(National Cheng Kung University)

Over the past few decades, rapid developments in space technology have advanced the research of ionospheric space weather by increasing a great number of ground- and space-based observations. In the ground segment, the dense ground-based GNSS networks, radars, and airglow instruments have greatly extended the observational coverages. In the space segment, the extraordinary satellite missions with payloads onboard the satellites providing radio occultation soundings of vertical electron density structure and in-situ observations of airglow, temperature, neutral winds, and electron density contribute to the understanding of middle and upper atmospheric dynamics. With the large amount and diversity of datasets, theoretical and empirical models can be validated and implemented for inclusion of new thermosphere and ionosphere phenomena. Furthermore, remarkable breakthrough of data assimilation techniques advances the ionosphere monitoring and forecast. The recent innovations in observations and models reinterpret the studies of ionospheric space weather. The purpose of this session is to solicit studies providing observations, theoretical and empirical modeling and data assimilation on the multiple scales of ionospheric phenomena, from global morphology to small-scale irregularities and traveling ionospheric disturbances. Studies on magnetically quiescent and disturbed conditions will be both addressed.

[PEM14-P01] The Daytime and Nighttime Mapped Whistler Plasmapause Observed by DEMETER

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[PEM14-P02] Global Plasma Density Irregularity Distributions Observed by Advanced Ionospheric Probe Onboard FORMOSAT-5 Satellite

*Chi-Kuang Chao[1], Yi-Wun Chen[1] (1.Graduate Institute of Space Science, National Central University)

[PEM14-P03] The First Result on Ionospheric Space Weather of FORMOSAT-5/AIP Ion Density

*FU-YUAN CHANG[1], JANN-YENQ Liu[1], Chi-Kuang Chao[1] (1.National Central University)

[PEM14-P04] The global total electron content reconstruction in the local time frame

*Tsung-Che Tsai[1,2], Hau-Kun Jhuang[3], Lou-Chuang Lee[3,4,5], Yi-Ying Ho[4] (1.National Center for High-Performance Computing, National Applied Research Laboratories, Hsinchu, Taiwan, 2.Department of Civil Engineering, National Chiao Tung University, Hsinchu, Taiwan., 3.Department of Geoscience, National Taiwan University, Taipei, Taiwan., 4.Institute of Earth Science, Academia Sinica, Nankang, Taipei, Taiwan., 5.Institute of Space Science, National Central University, Jhongli, Taiwan.)

[PEM14-P05] Research on impacts of power line harmonic radiation on ionospheric parameters

*Qiang Guo[1], Jing Wu[1], Ling Yang[1] (1.Beihang University)

[PEM14-P06] Analysis of cosmic rays dynamics and ionospheric parameters during increased solar activity and magnetic storms

*Oksana Mandrikova[1], Yurii Polozov[1], Bogdana Mandrikova[1,2] (1.Institute of Cosmophysical Research and Radio Wave Propagation, Far Eastern Branch of the Russian Academy of Sciences, 2.Saint Petersburg

Electrotechnical University "LETI")

[PEM14-P07] King Tidal Effects on the ionosphere during the period of 2000 to 2017

*TsungYu Wu[1], JANN-YENQ Liu[1] (1.Institute of Space Science, NCU, Taiwan)

[PEM14-P08] SuperDARN near range echoes and higher resolution measurement - recent improvement and future

*Akira Sessai Yukimatu[1,2] (1.National Institute of Polar Research, 2.SOKENDAI)

[PEM14-P09] **The ionospheric wave peak structures in the low latitude region and their seasonal, and solar activity dependence based on Global Ionosphere Maps**

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The Daytime and Nighttime Mapped Whistler Plasmapause Observed by DEMETER

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This paper investigates the plasmapause positions in the ionosphere by measurement of the whistler count probed by DEMETER (Detection of Electro-Magnetic Emissions Transmitted from Earthquake Regions) satellite in the daytime at 1030 LT (local time) and the nighttime at 2230 LT during 2005-2010. The whistler finds the plasmapause position which can be clearly allocated in both daytime and nighttime. We examine the nighttime/daytime plasmapause in various longitudes, solar activities, seasons, and geomagnetic actives. Results show that the daytime plasmapause appears in the equatorward side of the nighttime one. Both the daytime and nighttime plasmapause are sensitive to solar activity, which move equatorward form the low to high solar activity in the study period. The seasonal variation of the plasmapause are rather random and insignificant. During magnetic disturbed condition, the plasmapause tend to move equatorward.

Keywords: Plasmapause position, Whistler, DEMETER satellite

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Global Plasma Density Irregularity Distributions Observed by Advanced Ionospheric Probe Onboard FORMOSAT-5 Satellite

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A FORMOSAT-5 satellite has been launched on25 August 2017 CST into a 98.28° inclination sun-synchronous circular orbit at 720 km altitude along the 1030/2230 local time sectors. The orbital coverage provides a great opportunity to survey terrestrial ionosphere from equatorial to polar region every two days. Advanced Ionospheric Probe (AIP) is a piggyback science payload developed by National Central University for the FORMOSAT-5 satellite to measure ionospheric plasma concentrations, velocities, and temperatures. It is also capable of measuring ionospheric plasma density irregularities at a sample rate up to 8,192 Hz over a wide range of spatial scales. In this presentation/poster, distributions and structures of pre-midnight low-latitude ionospheric plasma density irregularities will be shown from AIP science data collected since winter 2017. Especially, seasonal variations of the distributions will be compared with ROCSAT-1/Ionospheric Plasma and Electrodynamics Instrument dataset (1999-2004) to understand their trends. Meanwhile, high resolution data measured at a BURST rate (8,192 Hz) in some longitudinal sectors with high plasma density irregularity occurrence rates will also be investigated by spectral analysis to understand their characteristics.

Keywords: AIP, FORMOSAT-5, Irregularities

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The First Result on Ionospheric Space Weather of FORMOSAT-5/AIP Ion Density

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1. National Central University

The science payload of Advantage Ionosphere Probe (AIP) onboard FORMOSAT-5 (F5) launched on 24 August 2017 has being operated in a Sun synchronous orbit at 720km altitude with an inclination angle of 98.28 degrees and the revisit period every 2-day. The global distribution of F5/AIP ion density (Ni) in nighttime of 2200LT during November 2017-October 2018 is examined and reported. F5/AIP ion densities show that equatorial plasma depletions frequently appear over South America, Africa, and Asia sectors; four-peaked EIA (non-migrating tide) structures prominently occur in September-March; and plasma depletion bays (PDBs) at low-latitudes in April-August. It is found that prominent locations of the plasma depletions slightly differ from those of equatorial irregularities, while non-migrating tide and PDBs result from different physical mechanisms.

Keywords: topside ionosphere, equatorial plasma depletion bay, plasma drift

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The global total electron content reconstruction in the local time frame

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The total electron content (TEC) data from Global Ionosphere Maps provide a global TEC map in the region between latitude 87.5˚S to 87.5˚N, and longitude 180˚W to 180˚E. The TEC data in geographic coordinates are first transformed into geomagnetic coordinates through Altitude-Adjusted Corrected Geomagnetic Model (AACGM). We then use 2-dimensional (longitude, 180˚W~180˚E and time, 10 days) Fourier transform (FT) of TEC variations along different geomagnetic latitude to obtain all wave modes for the period from November 18, to October 15, 2014. By the summation of all non-migrating tides, migrating tides, and zonal mean, the TEC global map in the local time frame is reconstructed. Again, the AACGM is applied to transform from geomagnetic coordinates back to geographic coordinates. The local time evolution in geographic coordinates of TEC is then produced. The features of TEC peaks in the local time frame are presented.

Keywords: geomagnetic coordinates, Global Ionospheric Maps, Fourier transform, Ionospheric tides

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Research on impacts of power line harmonic radiation on ionospheric parameters

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Introduction: Power line harmonic radiation (PLHR) refers to a kind of electromagnetic wave phenomena at harmonic frequencies of 50 or 60 Hz, which are the working frequencies of terrestrial power systems. Since the 1970s, PLHR events have been detected with several magnetically conjugate pairs of receivers and different satellites [1, 2, 3]. With the increase of global power consumption, PLHR has become more serious. Already, many scientific satellites have observed such anthropogenic electromagnetic waves in the ionosphere, and some possible typical impacts of those waves on the ionosphere have been reported [4]. However, reaching a final conclusion as to the impacts has been proven to be a difficult task. To further understand PLHR and its impacts, we utilize the data of three scientific payloads of DEMETER satellite collected with the Langmuir probe (ISL), thermal plasma analyzer (IAP), and energetic particle detector (IDP) to study the variation of ionospheric parameters due to the occurrence of PLHR.

Analytical Methods: DEMETER is a French seismo-electromagnetic microsatellite that was in operation from June 29, 2004 to December 9, 2010. The ISL onboard measured the electron density (N_e), electron temperature (T_e), and ion density (N_i). The IAP measured the density of H^+ (N_{H+}), He^+ (N_{He+}), O^+ (N_{O+}), and ion temperature (T_i). The IDP measured the electron fluxes in the range from 70 keV to 2.5 MeV. The variations of ionospheric parameters are affected by many factors, including latitude, longitude, altitude, daytime or nighttime, season, and solar activity. To minimize these impacts, we proposed an approach that compares the data from the PLHR-orbit and quiet-period orbit ($AE \leqq 50$ nT, AE is an index to evaluate the level of geomagnetic activity).

Among the 133 PLHR events detected by Wu et al. [5] when DEMETER flew over China, one quiet-period orbit, covering most of China's latitudes, was found for each year (2004-2010) according to AE index. In each PLHR-orbit, three-segment dataset were obtained: 30s before, at, and 30s after the occurrence region of PLHR event. By subtracting data of quiet-period orbit with corresponding latitudes from each-segment data of PLHR-orbit, we statistically analyzed the variation trend of ionospheric parameter in each PLHR-orbit due to PLHR.

Results & Discussion: With ISL and IAP data, it was found that both N_e and T_e were at a low level, N_{H+} was at a high level, and N_{O+} was at a low level when PLHR occurred. These results were generally helpful for understanding the formation behaviors of PLHR and were consistent with the theoretical results. From the analysis of IDP data, obvious variations of pitch angles before and after PLHR were occasionally observed to occur, and the variation did not exceed 10°. Its corresponding equatorial pitch-angle may not have fallen into a loss-cone, so the variation tendency of the electron flux did not have a definite connection with the pitch angle. The statistical results indicate that when PLHR occurs, the electron flux in the high-band (>1 MeV) tends to decrease and the decremental magnitude is very large, while the electron flux in the middle-band tends to increase and the incremental magnitude is relatively large.

Reference: [1] R. A. Helliwell, et al. (1975) *J. Geophys. Res-Space Phys.*, 80, 4249-4258. [2] J. P. Matthews, et al. (1981) *Planet. Space Sci.*, 29, 97-106. [3] M. Parrot, et al. (2014) *J. Geophys. Res-Space Phys.*, 119, 5744-5754. [4] M. Parrot, et al. (1996) *Surv. Geophys.*, 17, 67-100. [5] J. Wu, et al. (2017) *J. Geophys.*

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Res-Space Phys., 122, 3448-3458.

Keywords: power line harmonic radiation, ionospheric parameters, DEMETER

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Analysis of cosmic rays dynamics and ionospheric parameters during increased solar activity and magnetic storms

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Based on the ground station data, the paper makes complex analysis of cosmic ray dynamics and of ionospheric parameters during strong and moderate magnetic storms in 2015-2018. During the investigation, new methods of modeling and data analysis were applied. A neural network model for neutron monitor data classification was presented. This model makes it possible to evaluate galactic cosmic ray flux state and to detect periods of sporadic effect occurrences in automatic mode. By the use of this model, sporadic effects preceding and accompanying strong and moderate magnetic storms were detected. The model showed its efficiency when applied for data on-line analysis and for detection of sporadic effects including those of small amplitude. Ionospheric data were analyzed on the bases of multi-component modeling method and ionospheric parameter analysis [1, 2]. It allowed us to detect ionospheric disturbances of different intensity and to estimate their characteristics. The results of the work confirmed the possibility of ionospheric electron concentration increase effect preceding magnetic storm commencements [3]. Comparison with cosmic ray data showed the correlation of the effects in the ionospehre with anomalous changes in cosmic ray dynamics that was first mentioned in the paper [3].

1. Mandrikova O.V., Fetisova N.V., Polozov Y.A., Solovev I.S., Kupriyanov M.S. Method for modeling of the components of ionospheric parameter time variations and detection of anomalies in the ionosphere coupling of the high and mid latitude ionosphere and its relation to geospace dynamics // Earth, Planets and Space. 2015. Vol. 67. No 1. pp. 131-146. DOI: 10.1186/s40623-015-0301-4
2. O. Mandrikova, Yu. Polozov, V. Geppener Method of ionospheric data analysis based on a combination of wavelet transform and neural networks // «Procedia Engineering», Elsevier, Amsterdam, Netherlands, V.201, Pp. 756–766, DOI. https://doi.org/10.1016/j.proeng.2017.09.622.
3. Mandrikova O., Polozov Yu., Fetisova N., Zalyaev T. Analysis of the dynamics of ionospheric parameters during periods of increased solar activity and magnetic storms // Journal of Atmospheric and Solar-Terrestrial Physics. –2018. –Vol. 181. –Pp. 116-126. Doi: https://doi.org/10.1016/j.jastp.2018.10.019.

Keywords: cosmic rays, ionospheric parameters, data analysis

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King Tidal Effects on the ionosphere during the period of 2000 to 2017

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This study examines the spring tide signature of the 14.7-day period in concurrent/co-located measurements of the ionosphere total electron content (TEC) and sea level in an 18-year period of 2000-2017. A discrete Fourier transform is applied to find amplitude and phase of the spring tide in the TEC and sea level. Results show that the spring tide amplitude in the sea level is clear and steady, while that in the ionospheric TEC is rather fluctuated and proportional to the ambient TEC value. The relative amplitude of TEC in the 18-year is a function of the solar local time and become prominent in the daytime of 08:00-19:00. and however that in the nighttime 00:00-06:00 LT becomes prominent in 2002, 2005, 2009, and 2015, when the perihelion and perigee simultaneously occur. On the other hand, the phase of the spring tide signature in the sea level and TEC yield a 3-year period, which is close to the time interval of the above prominent spring tide signature in the nighttime. More detailed discussions and results will be presented.

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SuperDARN near range echoes and higher resolution measurement - recent improvement and future

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1. National Institute of Polar Research, 2. SOKENDAI

SuperDARN (Super Dual Auroral Radar Network) is an international high-frequency radar network originally intended to cover a wide range of polar ionosphere in both hemispheres by its fields-of-view and to monitor global ionospheric plasma convection in high temporal resolution of about 1-2 minitues in quasi real time mainly for space weather research. It can observe not only basic and important ionospheric plasma Doppler velocity and electric field, a variety of geomagnetic waves, ionospheric disturbances and irregularities, but also properties of neutral atmosphere, e.g., traveling ionospheric disturbances (TIDs), mesoepheric echoes like PMSEs and neutral wind around mesopause region. As it is originally designed to measure global large-scale ionospheric plasma parameters, the spatial resolution has been rather coarse, and it was originally difficult to obtain height information of echoes, high temporal resolution less than 1 second, and high spatial resolution of less than 15km in radial direction. Echo height information is very important especially to distinguish those among D, E and F regions as the properties of plasma among them are considerably different and also to obtain precise altitude of meteor echoes around mesopause due to existence of thin layers of neutral wind shear. Recent development in calibrating radar interferometry in SuperDARN community is an important step to improve much the reliability of height information especially in near range echoes and also of region identification for further echoes as well. Combining raw I/Q time series analysis method (Yukimatu and Tsutsumi, GRL, 2002) to be applied to extract underdense meteor echoes precisely, frequency domain interferometry (FDI) and/or over-sampling technique (Tsutsumi et al., 2009) with the appropriate interferometer calibration will improve the reliability and height resolution of the neutral wind measurement possibly leading to global neutral wind observing network around mesopause region with SuperDARN which will contribute to many studies on mesosphere-lower-thermosphere (MLT) or mesoephere-thermosphere-ionosphere (MTI) region dynamics and vertical coupling between ionosphere and neutral upper atmosphere. Another issue possibly critical for some specific studies, e.g., on short period electro-magnetic waves is possibility to achieve higher temporal resolution within a second as well as higher spatial resolution in range direction. (Higher spatial resolution in azimuth direction has been already tried and achieved by some radars using general imaging or spatial domain interferometry (SDI) technique.) There have been some trial against these possibilities with some success depending on the cases of the applied phenomena and the conditions of echoes, but have still been thought to be difficult to be overcome. This presentation will describe the evolution of SuperDARN near range echo measurement after last JpGU meeting, and will also discuss about the reliability of high temporal resolution measurement and the possible method to obtain reliable high temporal resolution data to extend the ability of SuperDARN.

Keywords: SuperDARN, near range echoes, electromagnetic waves, high temporal resolution

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The ionospheric wave peak structures in the low latitude region and their seasonal, and solar activity dependence based on Global Ionosphere Maps

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1. Department of Geosciences, National Taiwan University, Taipei, Taiwan, 2. National Center for High-performance Computing, National Applied Research Laboratories, Hsinchu, Taiwan, 3. Department of Civil Engineering, National Chiao Tung University, Hsinchu, Taiwan, 4. Institute of Earth Science, Academia Sinica, Nankang, Taipei, Taiwan, 5. Institute of Space Science, National Central University, Jhongli, Taiwan

The total electron content (TEC) data from Global Ionosphere Maps (GIM) are used to obtain the wave modes in both UT (universal time) and LT (local time) frames through the Fourier transform. The summation of contributing wave modes at a given local time provides the longitudinal variation of the wave peak structure. The phases of wave modes lead to a constructive or destructive interference of contributing wave modes, which gives different wave peak structure at different local time. The dependence of the wave peak structures on latitudinal, seasonal, and solar activity is studied.

Keywords: Global Ionosphere Maps, Ionospheric tides, Atmosphere Ionosphere coupling

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[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 201B 2F

[P-EM14] Recent Advances in Ionosphere Observation and Modeling for Monitoring and Forecast

convener:Yang-Yi Sun(China University of Geosciences), CHIYEN LIN(Center for Astronautical Physics and Engineering, National Central University, TAIWAN), MINYANG CHOU(National Cheng Kung University), Chairperson:Yang-Yi Sun

Over the past few decades, rapid developments in space technology have advanced the research of ionospheric space weather by increasing a great number of ground- and space-based observations. In the ground segment, the dense ground-based GNSS networks, radars, and airglow instruments have greatly extended the observational coverages. In the space segment, the extraordinary satellite missions with payloads onboard the satellites providing radio occultation soundings of vertical electron density structure and in-situ observations of airglow, temperature, neutral winds, and electron density contribute to the understanding of middle and upper atmospheric dynamics. With the large amount and diversity of datasets, theoretical and empirical models can be validated and implemented for inclusion of new thermosphere and ionosphere phenomena. Furthermore, remarkable breakthrough of data assimilation techniques advances the ionosphere monitoring and forecast. The recent innovations in observations and models reinterpret the studies of ionospheric space weather. The purpose of this session is to solicit studies providing observations, theoretical and empirical modeling and data assimilation on the multiple scales of ionospheric phenomena, from global morphology to small-scale irregularities and traveling ionospheric disturbances. Studies on magnetically quiescent and disturbed conditions will be both addressed.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[PEM14-01] New In-situ Ion Composition and Velocity Observations in the Topside Ionosphere from the Swarm-E Ion Mass Spectrometer

★Invited Papers

*Andrew W Yau[1] (1.University of Calgary)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[PEM14-02] **Spatial-time features and dynamics of ionospheric disturbances during magnetic storms in 2015-2018**

★Invited Papers

*Oksana Mandrikova[1], Nadezhda Fetisova[1], Yurii Polozov[1,2] (1.Institute of Cosmophysical Research and Radio Wave Propagation, Far Eastern Branch of the Russian Academy of Sciences, 2.Kamchatka State Technical University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[PEM14-03] Estimating 2D neutral wind patterns using line-of-sight data from multiple Scanning Doppler Imagers

*Heikki Vanhamaki[1], Shin-ichiro Oyama[1,2], Mark Conde[3], Anita Aikio[1], Lei Cai[4], Ilkka Virtanen[1] (1.University of Oulu, Finland, 2.Institute for Space-Earth Environmental Research, Nagoya University, Japan, 3.Geophysical Institute, University of Alaska Fairbanks, US, 4.KTH Royal Institute of Technology, Sweden)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[PEM14-04] **Comparison of empirical models for the location of the ionospheric middle-latitude trough in the nighttime**

*Sarah Park[1], Khan-Hyuk Kim[1] (1.School of Space Research, Kyung Hee University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PEM14-05] Research on nonlinear cross-modulation of power line emission and other very low frequency radiations in the ionosphere

*Ling Yang[1], Jing Wu[1], Qiang Guo[1] (1.Beihang University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PEM14-06] Ionospheric variation induced by 21 August 2017 total solar eclipse detected by Global Ionospheric Specification

*CHIYEN LIN[1,2], JANN-YENQ Liu[1,2,3], Charles Lin[4] (1.Center for Astronautical Physics and Engineering, National Central University, Taiwan, 2.Graduate Institute of Space Science, National Central University, Taiwan, 3.Center for Space and Remote Sensing Research, National Central University, Taiwan, 4.Department of Earth Science, National Cheng Kung University, Taiwan)

New In-situ Ion Composition and Velocity Observations in the Topside Ionosphere from the Swarm-E Ion Mass Spectrometer

*Andrew W Yau[1]

1. University of Calgary

The imaging and rapid-scanning ion mass spectrometer (IRM) onboard the polar-orbiting Swarm-E (e-POP) satellite is a new type of ion mass spectrometer that combines the techniques of hemispherical electrostatic deflection and ion time-of-flight analysis, with the unique capability of measuring simultaneously both the ion composition distribution and the detailed ion velocity distributions of individual ion species. We present several new observation results of the low, mid, and high-latitude topside ionosphere (300-1500 km altitude), from both detailed and statistical analyses of IRM data acquired in the first five years of the Swarm-E mission (since the launch in September 2013). These include the enhancement of minor ion composition at high latitudes, including N+ and molecular ions; localized regions of heavy ion up-flows and down-flows in the F-region auroral ionosphere; and bi-directional light ion flows at mid-latitudes; among others. We discuss the implications of these observation results in the context of both magnetosphere-ionosphere and ionosphere-thermosphere coupling.

Keywords: ionosphere, ion composition, ion mass spectrometer

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Spatial-time features and dynamics of ionospheric disturbances during magnetic storms in 2015-2018

*Oksana Mandrikova[1], Nadezhda Fetisova[1], Yurii Polozov[1,2]

1. Institute of Cosmophysical Research and Radio Wave Propagation, Far Eastern Branch of the Russian Academy of Sciences, 2. Kamchatka State Technical University

Ionospheric disturbances are formed as a result of ionosphere reaction to the increase in solar and geomagnetic activity (solar flares, coronal emissions, geomagnetic storms and substorms).They can have different intensity and duration and lead to the occurrences of positive and negative ionospheric storms. The ionospheric storm dynamics has complex spatial-time characteristics, depending on geographic location (polar and auroral zones, mid-latitude and equatorial regions), geomagnetic storm force, local time, and other factors. Ionospheric storms have negative impact on modern technical systems; therefore, their timely detection and prediction are an important task. In spite of the intensive development of technical tools and data analysis methods, the question of effective solution of this problem remains open [ex. 1].
In the paper, we modeled and analyzed the ionospheric parameter time course according to the ground station network (the resource http://wdc.nict.go.jp was used). Spatial-time features and dynamics of ionospheric disturbances were studied during magnetic storms which occured in 2015-2018. In the paper, a method proposed by the authors was used to model and to analyze ionospheric data. The method is based on wavelet transform [1]. The method allowed us to study the ionospheric parameter dynamics in detail, to detect ionospheric disturbances and to estimate their characteristics (Fig.1). The method was implemented numerically and adapted for real-time (as data are recorded). Comparison with the traditional approaches [2, 3] (median methods, IRI model) showed high efficiency of the proposed method and the possibility to apply it for on-line analysis of ionospheric data and to detect of ionospheric disturbances.

1. Mandrikova O.V., Fetisova N.V., Polozov Y.A., Solovev I.S., Kupriyanov M.S. Method for modeling of the components of ionospheric parameter time variations and detection of anomalies in the ionosphere coupling of the high and mid latitude ionosphere and its relation to geospace dynamics // Earth, Planets and Space. 2015. Vol. 67. No 1. pp. 131-146. DOI: 10.1186/s40623-015-0301-4
2. Mikhailov A., et al. A method for foF2 monitoring over Spain using the El Arenosillo digisonde current observations // Annals of Geophysics. 1999. Vol. 42 (4). doi:10.4401/ag-3748.
3. Bilitza D. International Reference Ionosphere 2007: Improvement sand new parameters / D. Bilitza, B.W. Reinisch // Advances in space research. 2008. Vol. 42. P. 599-609.

Keywords: Ionosphere, data analysis, ionospheric disturbances

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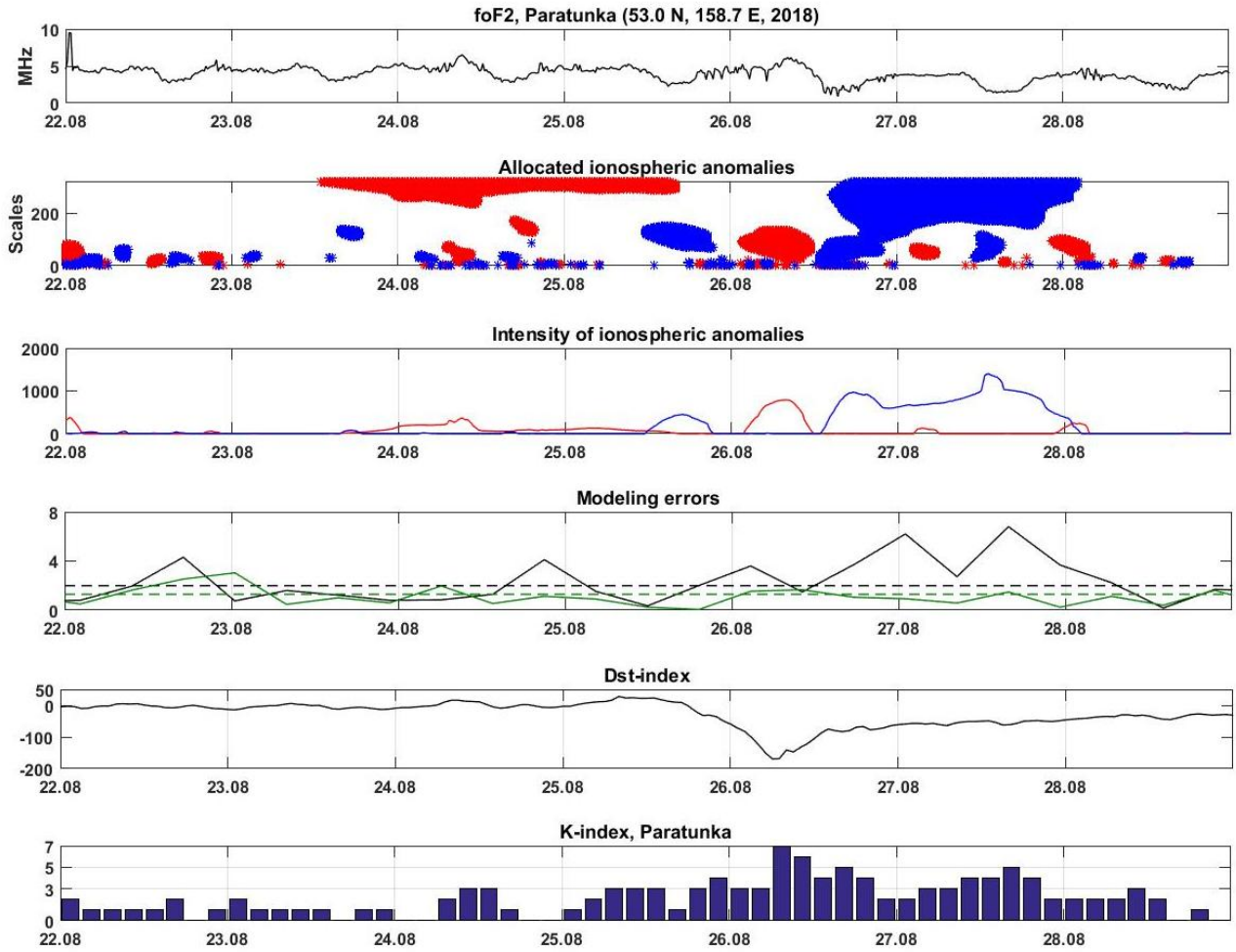

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Estimating 2D neutral wind patterns using line-of-sight data from multiple Scanning Doppler Imagers

*Heikki Vanhamaki[1], Shin-ichiro Oyama[1,2], Mark Conde[3], Anita Aikio[1], Lei Cai[4], Ilkka Virtanen[1]

1. University of Oulu, Finland, 2. Institute for Space-Earth Environmental Research, Nagoya University, Japan, 3. Geophysical Institute, University of Alaska Fairbanks, US, 4. KTH Royal Institute of Technology, Sweden

We present a new analysis technique for estimating 2D neutral wind pattern using data from a single Scanning Doppler Imager (SDI) or a combination of SDIs, incoherent scatter radars (ISR) and Fabry-Perot interferometers (FPI) within overlapping field-of-views. Neutral wind plays an important role in ionospheric electrodynamics and Ionosphere-Thermosphere coupling, by for example affecting the Joule heating rates and plasma transport. However, reliable and extensive measurements of the neutral wind are rather difficult to obtain.

Pointwise measurements can be obtained with ISRs or FPIs, but these measurements can not provide 2D latitude-longitude maps of the neutral wind pattern needed in mesospheric studies. A Scanning Doppler Imager can measure the line-of-sight (LOS) component of the neutral wind in dozens of directions simultaneously. However, further modeling is needed to convert the LOS velocities into 2D velocity maps. Unfortunately these maps are far from unique, as perpendicular velocities (e.g. rotation around the measurement site) are not visible in the LOS data. This can be mitigated by combining data from several nearby SDIs, or a combination of SDIs, FPIs and ISRs.

Our analysis technique is based on fitting the LOS data with special vector basis functions called Spherical Elementary Current Systems (SECS). In this approach the wind is naturally divided into curl-free and divergence-free components, and there is no need to provide any explicit boundary conditions on the wind pattern.

We present several synthetic test scenarios as well as first results using data from SDIs located in Alaska. Using the synthetic test scenarious we further estimate optimal locations for 2 or 3 SDIs that could be located around the future EISCAT_3D radar system in northern Scandinavia.

Keywords: Ionosphere, Thermosphere, Neutral wind

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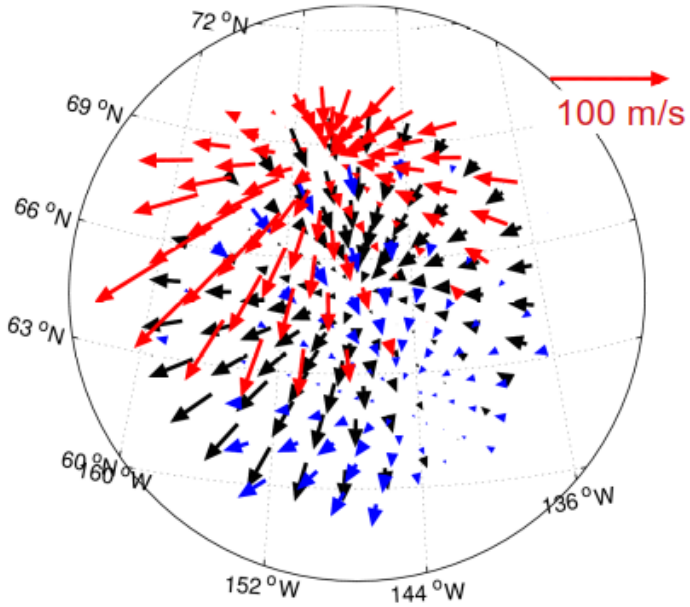
Line-of-sight velocity from 3 SDIs



Neutral wind pattern

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Comparison of empirical models for the location of the ionospheric middle-latitude trough in the nighttime

*Sarah Park[1], Khan-Hyuk Kim[1]

1. School of Space Research, Kyung Hee University

The middle-latitude ionization trough is a region of depleted plasma density in the ionosphere located at the equatorward edge of the auroral oval in the nighttime. Numerous studies have shown that trough locations shift equatorward under disturbed geomagnetic conditions. Many empirical models were developed to predict the trough location as a function of magnetic latitude (MLAT) and geomagnetic activity. Using the DMSP F15 data obtained in the nighttime sector of MLT = 1700-0130 hrs from February 2000 to January 2005, we identified 7735 middle-latitude troughs and statistically examined the trough location under different geomagnetic conditions. Unlike previous studies, we found that the middle-latitude trough minimum in the plasma density are distributed in a broad range of magnetic latitudes from ~40˚N to ~72˚N around 1700-2200 MLT in the Northern Hemisphere and from ~28˚S to ~76˚S around 2000-0130 MLT in the Southern Hemisphere depending on geomagnetic conditions. Trough locations at low latitudes and high latitudes, which appear under extremely disturbed (Kp > 6) and quiet (Kp < 1) geomagnetic conditions, respectively, are not well expected from previous empirical models. In this study, we develop an empirical model, in which trough locations can be expected under extreme geomagnetic conditions, and compare it with previous models.

Keywords: Ionospheric middle-latitude trough, Empirical model of the trough location

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Research on nonlinear cross-modulation of power line emission and other very low frequency radiations in the ionosphere

*Ling Yang[1], Jing Wu[1], Qiang Guo[1]

1. Beihang University

By analyzing the observation data on electric field intensity from DEMETER satellite, we found that there exists a special type of line radiation events in the ionosphere above China. Their time-frequency power spectrums have several parallel lines with the center frequency 19.8 kHz, interval 50 Hz/100 Hz, and bandwidth 10 Hz. This phenomenon mostly occurs above central and eastern regions of China, which are the magnetic conjugate point of NWC transmitter in Australia (21.81˚S, 114.16˚E) [1]. The 19.8 kHz-spectral line is considered from the transmitter, which generates signal with center frequency 19.8 kHz and frequency band 200 Hz.

We applied bicoherence spectral analysis [2] to the spectrum of these events and found that they are likely to be generated by the wave radiated from NWC transmitter nonlinearly cross-modulated by 50 Hz-power line emission (PLE) from Chinese power grid. We further used the theory of interaction of plane radio waves for the theoretical analysis on such nonlinear cross-modulation. This phenomenon indicates that radiation from ground power grid can not only directly propagate into the ionosphere, but also interact with other waves in the ionosphere and further change their original state.

Reference: [1] J. Macnae. (2015) *Geophysics*, 80, E343-E353. [2] D. B. Graham, et al. (2014) *Geophys. Res. Lett.*, 41, 1367-1374.

Keywords: power line emission, nonlinear cross-modulation, ionosphere, bicoherence spectral analysis

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Ionospheric variation induced by 21 August 2017 total solar eclipse detected by Global Ionospheric Specification

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1. Center for Astronautical Physics and Engineering, National Central University, Taiwan, 2. Graduate Institute of Space Science, National Central University, Taiwan, 3. Center for Space and Remote Sensing Research, National Central University, Taiwan, 4. Department of Earth Science, National Cheng Kung University, Taiwan

On 21 August 2017, a total solar eclipse passed through the continental United States (CONUS) from the west to the east coast. Total Electron Content (TEC) measurements from thousands ground-based GNSS (Global Navigation Satellite System) receiving stations over CONUS observe the ionospheric horizontal variation induced by the moon shadow. Meanwhile, Global Ionospheric Specification (GIS) is an ionospheric data assimilation product based on Gauss-Markov Kalman filter, to assimilate slant TEC observed from ground-based GPS receivers and space-based RO instrumentations into background model International Reference Ionosphere (IRI-2016) to provide the continuity ionospheric three-dimensional (3D) electron density distribution. In this study, GIS assimilates about 1000 ground-based GNSS receiving stations data over the CONUS to reconstruct 3D electron density distribution during the obscuration period. Comparison of integrated TEC, N_mF_2, and h_mF_2 for the eclipse day and the day before the eclipse day, the assimilation analysis results demonstrate that not only electron density is depleted and also the peak height is uplifted during the solar eclipse. These results also indicate that the GIS electron density can study ionospheric 3D structural variation.

Keywords: Data Assimilation, Ionosphere, Solar Eclipse

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[E] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 201B 2F

[P-EM14] Recent Advances in Ionosphere Observation and Modeling for Monitoring and Forecast

convener:Yang-Yi Sun(China University of Geosciences), CHIYEN LIN(Center for Astronautical Physics and Engineering, National Central University, TAIWAN), MINYANG CHOU(National Cheng Kung University), Chairperson:CHI-YEN LIN

Over the past few decades, rapid developments in space technology have advanced the research of ionospheric space weather by increasing a great number of ground- and space-based observations. In the ground segment, the dense ground-based GNSS networks, radars, and airglow instruments have greatly extended the observational coverages. In the space segment, the extraordinary satellite missions with payloads onboard the satellites providing radio occultation soundings of vertical electron density structure and in-situ observations of airglow, temperature, neutral winds, and electron density contribute to the understanding of middle and upper atmospheric dynamics. With the large amount and diversity of datasets, theoretical and empirical models can be validated and implemented for inclusion of new thermosphere and ionosphere phenomena. Furthermore, remarkable breakthrough of data assimilation techniques advances the ionosphere monitoring and forecast. The recent innovations in observations and models reinterpret the studies of ionospheric space weather. The purpose of this session is to solicit studies providing observations, theoretical and empirical modeling and data assimilation on the multiple scales of ionospheric phenomena, from global morphology to small-scale irregularities and traveling ionospheric disturbances. Studies on magnetically quiescent and disturbed conditions will be both addressed.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PEM14-07] Spatial gradients in the ionospheric delays (TECs) and scintillations associated with plasma bubbles

★Invited Papers

*Susumu Saito[1], Takayuki Yoshihara[1] (1.Electronic Navigation Research Institute, National Institute of Maritime, Port, and Aviation Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PEM14-08] Temporal and spatial variation of GPS TEC and phase scintillation during substorms and auroral breakups

*Paul Prikryl[1,2], James M. Weygand[3], Reza Ghoddousi-Fard[4], P. Thayyil Jayachandran[1], David R. Themens[1], Anthony M. McCaffrey[1], Bharat S. R. Kunduri[5], Emma Spanswick[6], Yongliang Zhang[7], Akira Sessai Yukimatu[8] (1.Physics Dept. of University of New Brunswick, Canada, 2.Geomagnetic Laboratory Natural Resources Canada, 3.Earth Planetary and Space Sciences, University of California, USA, 4.Canadian Geodetic Survey Natural Resources Canada , 5.Bradley Dept. of Electrical and Computer Engineering, Virginia Tech, USA, 6.Dept. of Physics and Astronomy of University of Calgary, Canada, 7.Johns Hopkins University Applied Physics Laboratory, USA, 8.National Institute of Polar Research, Japan)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PEM14-09] IGS ROTI Maps extension toward Southern Hemisphere and low latitudes

*Iurii Cherniak[1,2], Irina Zakharenkova[2], Andrzej Krankowski[2] (1.COSMIC Program Office, University Corporation for Atmospheric Research, 2.University of Warmia and Mazury in Olsztyn)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PEM14-10] Durations of ionospheric gradients and plasma bubbles as ionospheric threats to GBAS

*MAHO NAKAMURA[1], Susumu Saito[1], Takayuki Yoshihara[1] (1.Electronic Navigation Research Institute)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PEM14-11] Ionospheric Space Weather Data Product of FORMOSAT-7/COSMIC-2

★Invited Papers

*Charles Lin[1], P. K. Rajesh[1], CHIYEN LIN[2,3], Chia-Hung Chen[1], Jia-Ting Lin[1] (1.Department of Earth Sciences, National Cheng Kung University, 2.Center for Astronautical Physics and Engineering, National Central University, Taoyuan 32001, Taiwan, 3.Graduate Institute of Space Science, National Central University, Taoyuan 32001, Taiwan)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PEM14-12] **Vertical structure of ionosphere perturbed by large earthquake and tsunami**

*Yang-Yi Sun[1], XiangXiang Yan[1], Tao Yu[1], JANN-YENQ Liu[2] (1.China University of Geosciences (Wuhan), 2.National Central University)

Spatial gradients in the ionospheric delays (TECs) and scintillations associated with plasma bubbles

*Susumu Saito[1], Takayuki Yoshihara[1]

1. Electronic Navigation Research Institute, National Institute of Maritime, Port, and Aviation Technology

Spatial gradients in the ionospheric delays (equivalently ionospheric total electron contents: TECs) are the threat to the differential GNSS systems such as the ground-based GNSS augmentation system (GBAS), because they decorrelates the ionosphere induced errors between the reference and user stations. Another important issues is the scintillations associated with small-scale (a few hundred meters for GPS L1 signals at 1.57542 GHz) plasma irregularities. While the spatial gradient in the ionospheric delay may result in differential correction errors, the scintillation may result in increased noise of pseudo-range measurements, and in the worst case, cycle-slips and signal lock-off. Although both are associated plasma bubbles, they may not always occur simultaneously, partly because they are associated withplasma irregularities with different scale sizes.

In this study, correlation between the ionospheric spatial variation measured by a set of GNSS stations locate at the New Ishigaki Airport (24.3N, 124.2E) and the amplitude scintillation index (S4) observed near the airport are analyzed. The GNSS stations at the airport are separated by 0.1 - 2.3 km. The ionospheric delay differences are estimated based on the carrier-phase double differences with sophisticated methods originally developed for integrity monitors for GBAS. S4 index is estimated by a dedicated GNSS scintillation receiver. It was shown that the ionospheric delay gradients are not always enhanced when scintillation index is enhanced, though they are positively correlated. Further analysis of their correlations with different scale sizes by different combinations of GNSS receivers for ionospheric delay gradient estimation will be conducted, and the results will also be reported at the meeting.

Keywords: plasma bubble, spatial gradients in TEC, scintillations

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Temporal and spatial variation of GPS TEC and phase scintillation during substorms and auroral breakups

*Paul Prikryl[1,2], James M. Weygand[3], Reza Ghoddousi-Fard[4], P. Thayyil Jayachandran[1], David R. Themens[1], Anthony M. McCaffrey[1], Bharat S. R. Kunduri[5], Emma Spanswick[6], Yongliang Zhang[7], Akira Sessai Yukimatu[8]

1. Physics Dept. of University of New Brunswick, Canada, 2. Geomagnetic Laboratory Natural Resources Canada, 3. Earth Planetary and Space Sciences, University of California, USA, 4. Canadian Geodetic Survey Natural Resources Canada , 5. Bradley Dept. of Electrical and Computer Engineering, Virginia Tech, USA, 6. Dept. of Physics and Astronomy of University of Calgary, Canada, 7. Johns Hopkins University Applied Physics Laboratory, USA, 8. National Institute of Polar Research, Japan

Ionospheric structure caused by precipitation of energetic particles can adversely affect the GPS signals resulting in phase scintillation and cycle slips (loss of lock). GPS phase scintillation has been found correlated with auroral emission intensity, particularly with rapid changes in auroral forms and their brightness [1,2,3]. Total electron content (TEC) enhancements that were observed during substorm expansion phase within the night side downward (R1) current appear to be associated with enhanced precipitating particle fluxes [4]. Such TEC enhancements cause phase scintillation, which is most intense just after substorm onsets and auroral breakups. Phase scintillation index is computed for sampling rate of 50 Hz by specialized GPS scintillation receivers from the Canadian High Arctic Ionospheric Network (CHAIN). A proxy scintillation index is obtained from dual frequency measurements of geodetic-quality GPS receivers sampling at 1 Hz, which include globally distributed receivers of RT-IGS network that are monitored by the Canadian Geodetic Survey in near-real-time. Temporal and spatial changes of TEC and phase scintillation are investigated in the context of equivalent ionospheric currents derived from ground magnetometer network using the spherical elementary current method [5,6]. The relation of phase scintillation with auroral emission observed by THEMIS all-sky imagers and the far-ultraviolet scanning imager SSUSI onboard the DMSP satellites is also examined. In general, GPS phase scintillation is mapped to regions of strong westward electrojet (upward R2 currents or the interface with downward R1 currents) and to the poleward edge of the eastward electrojet (upward R1 currents). Following substorm onsets and auroral breakups, strong phase scintillation associated with TEC enhancements are mapped mainly to the upward R2 current or the equatorward edge of the downward R1 current at or near the Harang discontinuity region [7].

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[7] Weygand J.M., et al., J. Geophys. Res.. 113, A04213, 2008. doi:10.1029/2007JA012537

Keywords: Polar and auroral ionosphere (Ionospheric irregularities, Ionospheric currents, Energetic particles), Auroral substorms, GPS total electron content and phase scintillation

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IGS ROTI Maps extension toward Southern Hemisphere and low latitudes

*Iurii Cherniak[1,2], Irina Zakharenkova[2], Andrzej Krankowski[2]

1. COSMIC Program Office, University Corporation for Atmospheric Research, 2. University of Warmia and Mazury in Olsztyn

The International GNSS Service (IGS) has accepted for official release a new ionospheric product to characterize ionospheric irregularity and intensity as derived from multi-site ground-based GPS observations. This product routinely generated by multi-step processing of carrier phase delays in dual-frequency GPS signals and transferred to the IGS CDDIS database. These ROTI maps allow regular monitoring of ionospheric irregularities over the Northern Hemisphere where there is the highest concentration of the GNSS users. This product represents changes of the GPS-based index ROTI (Rate of TEC Index) and has a polar projection within a range of 50˚-90˚N in geomagnetic latitude and 00-24 magnetic local time and based on measurements with 30 s sampling rate from about 700 GPS representative stations located at high and middle latitudes of the Northern Hemisphere.As the highest concentration of the GNSS users is within the American, European and Asian sectors, initially it focused on the Northern Hemisphere auroral, and midlatitude regions. But plasma irregularities that occurred at high, middle, and low latitudes have different physical mechanisms of their origin and development. For investigation of the ionospheric irregularities climatology, study of the ionospheric responses for Space Weather events, processes derived from below, this actual ROTI Map product is required to be extended to low latitudes and the Southern hemisphere polar and midlatitudes.

Recently, a number of the ground-based receivers within the global and regional networks grew significantly. It offers an excellent opportunity to extend the current IGS ROTI maps product toward global coverage. We present initial results of improved ROTI maps product performance to characterize ionospheric irregularities exited by different types of geophysical processes and space weather events. The new ROTI maps product can be a valuable tool for retrospective analysis of plasma irregularities impact on the GNSS positioning in the “worst case” examination domain.

The research is supported by the National Science Centre, Poland, through grants 2017/25/B/ST10/00479 and 2017/27/B/ST10/02190.

Keywords: GPS, ionosphere, ionospheric irregularities, ROTI, IGS

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Durations of ionospheric gradients and plasma bubbles as ionospheric threats to GBAS

*MAHO NAKAMURA[1], Susumu Saito[1], Takayuki Yoshihara[1]

1. Electronic Navigation Research Institute

Ground-Based Augmentation System (GBAS) of global navigation satellite systems (GNSS) is now being widely deployed in the world. Ionospheric disturbances are one of the threats to GBAS operation because it is based on the differential GNSS (DGNSS) technique with L1 single frequency signals.In 2017, The International Civil Aviation Organization (ICAO) Asia-Pacific (APAC) region has defined the ionospheric threat model that can be used in the low magnetic latitude part of the region [1]. The threat model is being optimized for the transition region from low to mid-latitude regions over Japan by collecting more data using Japanese dense GNSS network (the GNSS Earth Observation NETwork: GEONET) [2,3,4].

Steep ionospheric delay gradients of which widths are several tens kilometers or less are one of the ionospheric threats in GBAS, because steep ionospheric gradients with small spatial scales may not be detected neither by GBAS ground stations nor by an airborne receiver when the gradient stands between the GBAS ground station and airplanes. From the viewpoint of GBAS operations, it is important to know how long such gradient events would last to predict the duration of GBAS operation outage. Therefore, clarifying durations of steep but small ionospheric gradients is important for GBAS operations. Though the duration of the ionospheric delay depletions associated with plasma bubbles have been studied extensively, the duration of the steep gradients have not been studied well.

In this paper, we extracted the steep ionospheric gradients caused by plasma bubbles from the ionospheric delay differences between some pairs of stations using the single-frequency-carrier-phase based and code-aided (SF-CBCA) technique [5] and GEONET data. Once the plasma bubbles candidates and the satellites which is affected by the ionospheric disturbances are selected, ionospheric delay variations of each receiver derived by dual-frequency measurements for estimation of the durations for each ionospheric gradient. The analyses of durations of steep ionospheric gradients which could be the threat for GBAS operations will be reported.

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Keywords: ionosphere, ionospheric threat model, plasma bubble, ionospheric gradient, GNSS, GBAS

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Ionospheric Space Weather Data Product of FORMOSAT-7/COSMIC-2

*Charles Lin[1], P. K. Rajesh[1], CHIYEN LIN[2,3], Chia-Hung Chen[1], Jia-Ting Lin[1]

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FORMOSAT-7/COSMIC-2 (F7/C2) will provide unprecedented number of ionosphere observations in the mid- and low-latitude regions where the ionosphere is highly variable due to its interactions with planetary waves, solar oscillations, and lunar tides overlapping on top of the original ionospheric climatological electron density morphologies. To study the strong day-to-day variability of the ionosphere there, we have developed a global ionospheric data assimilation model using radio occultation observations together with auxiliary observations from ground-based GNSS stations. The assimilation system is capable of producing day-to-day and hour-to-hour ionospheric electron density maps three dimensionally for the study. With the advance given by the newly developed data assimilation model, we re-examine the wave-4 variations on daily basis, as well as the migrating tidal variations during the stratospheric sudden warming events. Additionally, electron density profiles from the aided Abel inversion of radio occultation observations will also be provided which is expected to give more reliable electron density profile around 200-300 km altitude compared with traditional Abel inversion. The abovementioned ionosphere products from the F7/C2 observations will be available six months after launch.

Keywords: FORMOSAT-7/COSMIC-2, Space Weather

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Vertical structure of ionosphere perturbed by large earthquake and tsunami

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1. China University of Geosciences (Wuhan), 2. National Central University

The FORMOSAT-3/COSMIC (F3/C) radio occultation (RO) technique vertically scans the atmosphere from 0 to 800 km altitude. Here we first show the ionospheric electron density structures which were perturbed by the wavefront of the M_W7.8 Nepal earthquake that occurred on 25 April 2015. Next, we show the acoustic resonance due to the 2008 Mw8.0 Wenchuan earthquake and 2011 Mw9.0 Tohoku earthquake and tsunami. The mean wavelet spectra derived from dozens of atmospheric and ionospheric RO sounding profiles within six hours after the earthquake illustrate that the atmospheric oscillations with the vertical wavelength ranging from 0.5 to 60 km appear at the altitudes from the lower atmosphere to the ionosphere. The vertical wavelength estimated from the atmospheric gravity wave dispersion relation is compared with the observed vertical wavelength. The small-scale gravity waves may not be easy to reach the upper ionosphere. These RO-observed long-lasting atmospheric and ionospheric oscillations may consist of the earthquake/tsunami wavefront and its residual oscillatory tail or acoustic resonance. The results suggest that the RO technique is a powerful tool which is suitable for probing earthquake/tsunami-induced oscillations in the atmosphere, and allow a more comprehensive understanding of the excitation, propagation, and dissipation of earthquake/tsunami-induced gravity waves in the entire atmosphere.

Keywords: coseismic traveling ionospheric disturbance, wavefront, resonance, radio occultation

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[J] Poster | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_2

[P-EM19] Frontiers in the solar physics

convener:Shinsuke Imada(Institute for Space-Earth Environmental Research, Nagoya University), Takaaki Yokoyama(School of Science, University of Tokyo), Toshifumi Shimizu(Institute of Space and Astronautical Science, JAXA), Yukio Katsukawa(National Astronomical Observatory of Japan, National Institute of Natural Sciences)

To date, we have three Japanese satellite missions to observe solar atmosphere, i.e., "Hinotori", "Yohkoh", and "Hinode", and revealed very dynamic nature of the solar atmosphere.These satellite observations allow us to see magnetic activities in the corona in X-ray, which cannot be obtained by ground-based telescopes. Also, thanks to seeing free condition, "Hinode" continuously observes the magnetic field in the photosphere. From these experiences, we have learned following three important requirements for the future missions to solve "coronal heating" and "solar flare" problems;1) seamless and simultaneous observation covering all temperature regimes from the photosphere to the corona, 2) high spatial and temporal resolution to resolve elemental structures and to track their evolution, 3) plasma diagnostic capability to quantify the dynamics of elementary processes. Recently, solar physics community in Japan proposed Solar-C_EUVST mission which is intended to be launched in middle of 2020s. Further, next-generation instruments, such as Parker Solar Probe (PSP), the Daniel K. Inouye Solar Telescope (DKIST), and SUNRISE will appear even before Solar-C_EUVST. Several proposals, e.g., PhoENiX, are also appearing. We will discuss in this session what we should study for further understanding of solar physics from current observations and numerical simulations and what we must prepare before 2020s. We welcome participations and presentations especially from Solar Terrestrial Physics (STP) community.

[PEM19-P01] Onset Mechanism of the Largest Solar Flare in Solar Cycle 24

★Invited Papers

*Yumi Bamba[1,2], Satoshi Inoue[1], Shinsuke Imada[1], Kanya Kusano[1] (1.Institute for Space-Earth Environmental Research/Nagoya University, 2.Institute if Space and Astronautical Science/Japan Aerospace Exploration Agency)

[PEM19-P02] Infrequent Occurrence of Significant Linear Polarization in H-alpha Solar Flares

*Tomoko Kawate[1], Yoichiro Hanaoka[2] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.National Astronomical Observatory of Japan)

[PEM19-P03] Statistical study of solar flares simultaneously observed with RHESSI and Nobeyama Radioheliograph

*Satoshi Masuda[1], Sam Krucker[2,3], Stephen White[4] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.University of Applied Sciences Northwestern Switzerland, 3.University of California, Berkeley, 4.Air Force Research Laboratory)

[PEM19-P04] Microwave turn-over frequencies and emission temperatures for white-light solar flares

*Kosuke Tsuruda[1], Kyoko Watanabe[1], Satoshi Masuda[2], Säm Krucker[3] (1.National Defense Academy , 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.University of Applied Sciences Northwestern Switzerland, UC Berkeley)

[PEM19-P05] Stellar flare of a close binary system monitored by the Hisaki satellite during the NICER-Hisaki Observing Campaign 2018-2019

*Tomoki Kimura[1], Wataru Iwakiri[2], Atsushi Yamazaki[3], Go Murakami[3], Fuminori Tsuchiya[4], Kazuo Yoshioka[5], Shin Toriumi[6], Hajime Kita[3], Masaki Kuwabara[3] (1.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 2.Faculty of Science and Engineering, Chuo University, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 4.Planetary Plasma

and Atmospheric Research Center, Tohoku University, 5.Department of Complexity Science and Engineering, University of Tokyo, 6.National Astronomical Observatory of Japan)

[PEM19-P06] Solar Neutron and Gamma-ray Observations with a 3U CubeSat

*Kazutaka Yamaoka[1], Hiroyasu Tajima[1], Kikuko Miyata[2], Takaya Inamori[2], Yoshinori Sasai[1], Kazuhiro Nakazawa[3], Satoshi Masuda[1], Koji Matsushita[4], Kazuya Itoh[4], Hiromitsu Takahashi[5], Kyoko Watanabe[6] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.School of Engineering, Nagoya University, 3.School of Science, Nagoya University, 4.Technical Center, Nagoya University, 5.School of Science, Hiroshima University, 6.National Defence Academy of Japan)

[PEM19-P07] Magnetic Flux Cancelation as the Buildup and Trigger Mechanism for CME-Producing Eruptions in two Small Active Regions

*Alphonse Sterling[1], Ronald L Moore[1,2], Navdeep K Panesar[1] (1.NASA/MSFC, 2.CSPAR, University of Alabama Huntsville)

[PEM19-P08] Estimation of turbulent pumping in the solar near-surface convection zone

*Haruhisa Iijima[1], Hideyuki Hotta[2], Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Graduate School of Science, Chiba University)

[PEM19-P09] Evaluation of the influence of the next solar cycle by sunspots using surface flux transport model

*Yusaku Watanabe[1], Shinsuke Imada[1], Haruhisa Iijima[1], Yoshizumi Miyoshi[1] (1.Institute for Space–Earth Environmental Research, Nagoya University)

[PEM19-P10] The image analysis of sunspot sketches in Dalton minimum(the early 1800s)

*SHOMA UNEME[1], Shinsuke Imada[1], Hisashi Hayakawa[2], Yoshizumi Miyoshi[1] (1.Nagoya University Institute for Space Earth for Enviornmental research, 2.Osaka University School of Letters)

[PEM19-P11] Observations of Photospheric Magnetic Structure below a Solar Dark Filament

*Takaaki Yokoyama[1], Yukio Katsukawa[2], Masumi Shimojo[2] (1.School of Science, The University of Tokyo, 2.National Astronomical Observatory of Japan)

[PEM19-P12] Science Target of Solar-C_EUVST Mission

*Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

Onset Mechanism of the Largest Solar Flare in Solar Cycle 24

*Yumi Bamba[1,2], Satoshi Inoue[1], Shinsuke Imada[1], Kanya Kusano[1]

1. Institute for Space-Earth Environmental Research/Nagoya University, 2. Institute if Space and Astronautical Science/Japan Aerospace Exploration Agency

Solar active region (AR) NOAA 12673, which appeared on the solar surface in September 2017, showed us amazing grows of magnetic field and produced numbers of flares including four X-class flares. We focused on the X2.2 and X9.3 flares that occurred while rapid growth of the AR on September 6, because latter the X9.3 flare caused increase of disturbances in ionosphere and magnetosphere. We aimed to understand the onset mechanism(s) of the X-class flares. Hence we analyzed the data obtained by Hinode and Solar Dynamics Observatory (SDO), and compared the analysis results to nonlinear force-free field (NLFFF), which is extrapolated from observed vector magnetic field.

We revealed that the key feature to trigger the X-class flares is the negative polarity region that emerged in the east in the AR and rapidly intrude into the positive polarity region. Highly sheared fields were located along the intruding negative field, and those were elongated and were pressed along with the intruding motion. Then the sheared fields were reconnected, and that could be a trigger of X-class flares. Hinode and SDO observed proxies of the magnetic reconnection, such as fast (over 100 km/s) down flow and brightening in the solar corona, over the intruding negative field approximately 2 hours before the X2.2 flare onset. The NLFFF has several small flux ropes that lying along the magnetic polarity inversion line. We found that a part of those flux ropes erupt in our magnetohydrodynamics (MHD) simulation. Therefore, a possibility that the intruding motion of the negative field would drive the flux rope to unstable state. This would cause the X2.2 small eruption. Following the X2.2 eruption, we further found that a new flux rope, which is larger and highly twisted, is formed by the reconnection between another small flux ropes, that shows dramatic eruption. We suggest that this eruption causes the X9.3 flare. In fact, the continuous intruding motion of negative field is observed after the X2.2 flare, therefore it would play an important role in producing the X9.3 flare.

From these results, we propose the scenario that the sequential X2.2 and X9.3 flares were triggered by push-mode-like magnetic reconnection corresponding to the intruding motion of the negative polarity field. We also discuss possibility of another triggering scenario such as emerging flux that has specific features of so-called the reversed shear type.

Keywords: Solar Flare, Hinode, Solar Dynamics Observatory, Flare Trigger, Solar Magnetic Field, Sunspot

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Infrequent Occurrence of Significant Linear Polarization in H-alpha Solar Flares

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We performed statistical and event studies of linear polarization in the H-alpha line during solar flares. The statistical study revealed that, among 71 H-alpha flares analyzed, including 64 GOES flares, only one event shows significant linear polarization signals. Such an infrequent occurrence of significant linear polarization in solar flares is consistent with the result by Bianda et al. (2005), who studied 30 flares and found no polarization signals. In the event showing the significant polarization, the maximum degree of linear polarization was 1.16±0.06%, and the average direction of the polarization deviated by -142.5±6.0 degrees from the solar north. The observed polarization degrees and the directions are consistent with the preceding reports. These strong linear polarization signals did not appear at major flare ribbons, nor did they correlate with either hard or soft X-ray emissions temporally or spatially. Instead they appeared at a minor flare kernel, which corresponds to one of the footpoints of a coronal loop. The active region caused coronal dimming after the soft X-ray peak. The observed flare show no direct evidence that the linear polarization is produced by high energy particles, which are often considered to generate the polarization. On the other hand, our study suggests the possibility that coronal mass ejections, which have been often observed in flares showing linear polarization signals, play an important role for exciting linear polarization at H-alpha flare kernels.

Keywords: Solar flare, Atomic Polarization, visible light

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Statistical study of solar flares simultaneously observed with RHESSI and Nobeyama Radioheliograph

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Solar flares give us a unique opportunity to make spatially resolved observations to study magnetic energy release and particle acceleration in space plasmas. The most direct diagnostics of electron acceleration are provided through radio and hard X-ray observations where we observe synchrotron emissions in the GHz range and non-thermal bremsstrahlung emissions above typically 10 keV. The two leading solar dedicated observatories in these two wavelength ranges are the Nobeyama Radioheliograph (NoRH) and the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI).
We present a statistical study of 35 jointly observed big (>GOES M7) flares. Initial results reveal a linear correlation between the hard X-ray flux above 50 keV and the microwave fluxes at 17 and 34 GHz. This result indicates that the population of accelerated electrons emit both of hard X-rays and microwaves. The correlation is too good even if this is true. Because the mechanism of these two emissions (hard X-rays and microwaves) are much different. Hard X-rays are emitted by Bremsstrahlung and its intensity simply depends on the flux of the accelerated electrons precipitating into the chromosphere in the case that the thick-target model is valid. However, microwaves emitted by gyro-synchrotron are a little complex. The microwave source is observed at different location for flare by flare, i.e. near the looptop, at the footpoint region, and in between them. Footpoint region has much stronger magnetic field than the looptop region. Gyro-synchrotron emission is very sensitive to magnetic field strength. Though the microwave intensity may strongly depend on the source location, however, microwave intensity without any selection by source location shows a very good correlation with hard X-rays. Another puzzle is the energy spectrum of accelerated electrons. Roughly speaking, 50 keV hard X-rays are manly emitted by below 100 keV electrons. On the other hand, 17GHz and 34GHz microwaves are typically emitted by ~1 MeV electrons (it depends on the magnetic field strength of the emitting region). Typically accelerated electrons show a power-law spectrum with the power-law index 3 –6. The power-law index is different in flare by flare. When the number of 100 keV electrons is fixed, the number of 1 MeV electrons changes in 3 order of magnitudes with the change of the power-law index from 3 to 6. The microwave intensity is proportional to the number of ~1 MeV electrons. So roughly thinking, the ratio between hard X-rays and microwave intensity easily change with the change of the power-law index. Without considering the spectral information, we choose the events. However, still there is a very good correlation. This is also a hard puzzle.
In order to understand this too good correlation between hard X-ray and microwave intensity, we need further analyses such as source location of hard X-ray and microwaves, hard X-ray spectrum, photospheric magnetic field at the footpoint region, location of the flare on the solar disc, and so on.

Keywords: solar flare, particle acceleration, radio, hard X-ray

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Microwave turn-over frequencies and emission temperatures for white-light solar flares

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It is believed that the origin of white-light enhancement, which is usually associated with large solar flare, is accelerated non-thermal electrons. The relationship between emission measure and temperature of white-light flares (WLFs) supported the existence of strong magnetic field around the acceleration site (Watanabe et al., 2017). Although the field strength at the acceleration site cannot measure directly, it can be estimated by using the turn-over frequency of gyro-synchrotron emission in microwaves (Dulk 1985). Kitagawa (2015, master thesis) suggested the existence of strong magnetic field on WLFs because the turn-over frequencies of WLFs were higher than those of no white-light flares (NWLFs), by the microwave spectra observed with the Nobeyama Radio polarimeters (NoRP).

We performed a statistical analysis of microwave turn-over frequencies for >M3 class flares during the period from January 2011 to December 2017. We found 51 events which were simultaneously observed with white-light (*Hinode*/SOT and/or *SDO*/HMI) and microwave (NoRP), however, we couldn't find any difference in turn-over frequencies for WLF and NWLF. We thought this result might be due to the difference of the location (loop-top or foot-point) of the microwave source in each flare. Then we checked the location of microwave emission by comparing with images of *SDO*/AIA (193Å), Nobeyama Radio heliograph (NoRH, 17GHz), and/or RHESSI (30-80 keV). Finally we found 29 flares (WLF: 17 events, NWLF: 12 events) have a dominant microwave source around the loop-top. When we checked turn-over frequencies for these events, only 7 events (WLF: 4 events, NWLF: 3 events) have higher turn-over frequencies than 17 GHz, and no clear difference was found between WLF and NWLF. Because the turn-over frequency is determined by not only the field strength but also the electron density (Dulk 1985), we have to think about the variation of electron density for this study.
On the other hand, durations of flare were clearly differing in WLF and NWLF, and WLFs are well associated with impulsive flares (Watanabe et al., 2017). However, there are some impulsive flares that do not have any white-light enhancements. In order to check the effect of flare duration (impulsivity) for white-light emission, a statistical analysis of emission temperature for WLFs is one of the effective approaches. So we derive emission temperature from three-color continuum data of *Hinode*/SOT (red, green, and blue) for ~40 events (e.g. Watanabe et al., 2013; Kerr & Fletcher, 2014), and discuss the relationship with flare impulsivity.

Keywords: flares, radio radiation

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Stellar flare of a close binary system monitored by the Hisaki satellite during the NICER-Hisaki Observing Campaign 2018-2019

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Dynamics of stellar flare is still not well understood compared to that of the sun because of lack of continuous monitoring of distant stars in multiple wavelengths. Here we present a flare event at a close binary system, UX Arietis, monitored with the planetary extreme ultraviolet (EUV) space telescope Hisaki during the coordinated observing campaign with the NICER X-ray Telescope from late 2018 to early 2019. Time variability in the EUV spectrum of the binary was successfully monitored from the begging to the end of flare. Emission power at the EUV wavelengths peaked at ~6x10^24 W, which is comparable with that measured in the previous X-ray observations by e.g., the Advanced Satellite for Cosmology and Astrophysics (ASCA) (Gudel et al., 1999). The EUV spectrum showed emission lines of carbon, nitrogen, oxygen, and silicon ions. Electron temperature and density, emission measure, and ion balance were reduced from the emission lines by EUV spectral diagnostics. Dynamics of the stellar flare will be discussed based on comparison of the reduced plasma parameters with the X-ray spectrum measured with NICER.

Keywords: stellar flare, Hisaki

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Solar Neutron and Gamma-ray Observations with a 3U CubeSat

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Solar neutron observations are very important on understanding of particle acceleration mechanism in the Sun. However, previous ground-based observations with large area telescope (~10 m2)at high latitude are not sensitive to solar neutrons due to attenuation in the earth atomsphere and roughly 10 detection since its discovery in 1980 (Chupp et al. 1982). From space, the SEDA-AP instrument with much smaller area (100 cm^2) onboard the International Space Station (ISS) monitored solar neutrons including charged particles, and successfully detected more than 30 detection since its launch in 2009 (Muraki et al. 2014). Unfortunately the SEDA-AP operation was stopped on March 2018. To overcome situation for no mission dedicated for solar neutrons, we have designed and developed a solar neutron and gamma-ray detector for a 3U cubesat with a size of 30x10x10 cm. Actually we launched the 50-kg class ChubuSat-2 satellite for solar neutron observations on February 2016 (Yamaoka et al. 2016), and have now been modifying it to a 3U cubesat application. for the launch in 2021. The solar neutron and gamma-ray detector consists of multi-layered plastic scintillator bars, and GAGG(Ce) scintillator array, and both of them are read out with silicon photo-multipliers (Si PMs). More than 600 signals from Si PMs are processed by IDEAS ASICs. In this paper, we will describe scientific motivation, details of the detector and performance of its breadboard model (BBM).

Keywords: sun, Neutron, gamma-ray, detector, micro-satellite

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Magnetic Flux Cancelation as the Buildup and Trigger Mechanism for CME-Producing Eruptions in two Small Active Regions

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We follow two small, magnetically isolated CME-producing solar active regions (ARs) from the time of their emergence until several days later, when their core regions erupt to produce the CMEs. In both cases, magnetograms show: (a) following an initial period where the poles of the emerging regions separate from each other, the poles then reverse direction and start to retract inward; (b) during the retraction period, flux cancelation occurs along the main neutral line of the regions, (c) this cancelation builds the sheared core field/flux rope that eventually erupts to make the CME. In the two cases, respectively 30% and 50% of the maximum flux of the region cancels prior to the eruption. Recent studies indicate that solar coronal jets frequently result from small-scale filaments eruptions (Sterling et al. 2015), with those “minifilament” eruptions also being built up and triggered by cancelation of magnetic flux (Panesar et al. 2016). Together, the small-AR eruptions here and the coronal jet results suggest that isolated bipolar regions tend to erupt when some threshold fraction, perhaps in the range of 50%, of the region’s maximum flux has canceled. Our observed erupting filaments/flux ropes form at sites of flux cancelation, in agreement with previous observations. Thus, the recent finding that minifilaments that erupt to form jets also form via flux cancelation is further evidence that minifilaments are small-scale versions of the long-studied full-sized filaments. (Details are in Sterling et al. 2018, ApJ, 864, 68.) This work was supported by the NASA HGI Program, and the NASA/MSFC NPP program.

Keywords: Sun: Filaments, prominences, Sun: Magnetic fields, Sun: Flares, Sun: CMEs

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Estimation of turbulent pumping in the solar near-surface convection zone

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We estimate the turbulent transport coefficients of the mean field model of solar dynamo process using the three-dimensional radiation magnetohydrodynamic simulations. The number of studies has been devoted to investigate the mean field description of the solar dynamo process. Large uncertainty of this model comes from the turbulent transport coefficients like the turbulent diffusion, alpha effect, or turbulent pumping. Although various numerical and observational studies has been estimated the turbulent transport coefficients, very few studies focused on the near-surface values of the vertical transport coefficients. These vertical transport coefficients in the near-surface convection zone is important for characterizing the upper boundary of the solar dynamo models. In this study, we estimate the vertical transport coefficients such as the turbulent diffusion and pumping using the large-eddy numerical simulation. The realistic near-surface convection is modeled by the three-dimensional radiation magnetohydrodynamic simulations. In the presentation, we report the wavenumber dependence of the transport coefficients and suggest a suitable upper boundary condition of the solar dynamo models.

Keywords: Sun, Turbulence, Dynamo

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Evaluation of the influence of the next solar cycle by sunspots using surface flux transport model

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1. Institute for Space–Earth Environmental Research, Nagoya University

Predicting the next solar cycle and finding its schemes are a key for the long-term space weather research. Recent studies suggest that there is the correlation between polar magnetic field at the solar minimum and the next solar activity. Iijima et al. (2017) calculated the polar transport of the sunspots by using the surface flux transport model (SFT) and predicted the polar magnetic field at the solar minimum concluded that next solar cycle is weaker than the present. To evaluate their result, we have calculated the time evolution of the solar magnetic field for specific active region by SFT, and discussed the discrepancy between the model result and observations obtained by Helioseismic and Magnetic Imager (HMI). The peculiar example of the observation data is the active region AR12673 which occurred X9.3 solar flare on September 6, 2017 and played a role of weakening the negative magnetic field in the southern polar region. Meanwhile, AR12674 which appeared at the same time strengthened the positive magnetic field in the northern polar region, so we found the prediction result is different before and after the appearance of these active regions. Regarding the active regions after these, it is thought the influence is small because the transport to the polar region cannot be completed in time to the solar minimum. We confirmed reproducibility of polar transport in the model continuously using the actual magnetic field distribution from 2010 to the end of 2018 and the reproducibility 80 %, and found the activity of the next solar cycle is to be about 5 to 10 % stronger than present.

Keywords: Sun, Space weather, Magnetic fields

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The image analysis of sunspot sketches in Dalton minimum(the early 1800s)

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1. Nagoya University Institute for Space Earth for Enviornmental research, 2. Osaka University School of Letters

Solar activity changes periodically in 11 years. Because the solar activity is one of the main origins of the variability of the solar-terrestrial environment, it is important to predict the solar activity especially in the category of space weather study. It is known that the polar magnetic field at the solar minimum is closely correlated with the solar activity at the next solar activity. This correlation was confirmed by observing the current sun precisely. On the other hand, it is not clear whether there was a similar correlation in the past sun. Therefore, the aim of this study is to analyze the past sun spot sketch images to verify whether the polar field value at the solar minimum is also good correlation with the next solar activity. Especially, we focused on the Dalton minimum when sun spots were little in the early 1800s. We extracted latitude and longitude of sun spot from sketches in the early 1800 's. We will discuss the differences between the result obtained in this analysis and the characteristics of current sun. As a future plan, we calculate the surface magnetic flux transport model based on these obtained sun spot information and estimate the value of the polar magnetic field at the solar minimum of the Dalton minimum.

Keywords: sun, Dalton minimum, sketch, SFT

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Observations of Photospheric Magnetic Structure below a Solar Dark Filament

*Takaaki Yokoyama[1], Yukio Katsukawa[2], Masumi Shimojo[2]

1. School of Science, The University of Tokyo, 2. National Astronomical Observatory of Japan

The structure of the photospheric vector magnetic field below a dark filament on the Sun is studied using the observations of the Spectro-Polarimeter attached to the Solar Optical Telescope onboard Hinode. Special attention is paid to discriminate the two suggested models, a flux rope or a bent arcade. "Inverse-polarity" orientation is possible below the filament in a flux rope, whereas "normal-polarity" can appear in both models. We study a filament in active region NOAA 10930, which appeared on the solar disk during 2006 December. To know whether it is in the normal orientation or in the inverse one under 180-degree ambiguity of the transverse field, the center-to-limb variation is used for the solution under an assumption that the filament does not drastically change its magnetic structure during the passage. When the filament is near the east limb, we found that the line-of-site magnetic component below is positive, while it is negative near the west limb. This change of sign indicates that the horizontal photospheric field perpendicular to the polarity inversion line beneath the filament has an "inverse-polarity", that is indicating a flux-rope structure of the filament supporting field.

Keywords: Sun, filament, photosphere

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Science Target of Solar-C_EUVST Mission

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1. Institute for Space-Earth Environmental Research, Nagoya University

Solar-C EUVST (EUV High-Throughput Spectroscopic Telescope) is designed to comprehen- sively understand the energy and mass transfer from the solar surface to the solar corona and interplanetary space, and to investigate the elementary processes that take place universally in cosmic plasmas. The proposed mission is a fundamental step for answering how the plasma universe is created and evolves, and how the Sun influences the Earth and other planets in our solar system. The two primary science objectives for Solar-C EUVST are : I) Understand how fundamental processes lead to the formation of the solar atmosphere and the solar wind, II) Understand how the solar atmosphere becomes unstable, releasing the energy that drives solar flares and eruptions. Solar-C EUVST will, A) seamlessly observe all the temperature regimes of the solar atmosphere from the chromosphere to the corona at the same time, B) resolve elemental structures of the solar atmosphere with high spatial resolution and cadence to track their evolution, and C) obtain spectroscopic information on the dynamics of elementary pro- cesses taking place in the solar atmosphere. In this talk, we will discuss the science target of the Solar-C EUVST.

Keywords: Sun, corona, spectroscopy

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[J] Poster | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_6

[P-EM19] Frontiers in the solar physics

convener:Shinsuke Imada(Institute for Space-Earth Environmental Research, Nagoya University), Takaaki Yokoyama(School of Science, University of Tokyo), Toshifumi Shimizu(Institute of Space and Astronautical Science, JAXA), Yukio Katsukawa(National Astronomical Observatory of Japan, National Institute of Natural Sciences)

To date, we have three Japanese satellite missions to observe solar atmosphere, i.e., "Hinotori", "Yohkoh", and "Hinode", and revealed very dynamic nature of the solar atmosphere.These satellite observations allow us to see magnetic activities in the corona in X-ray, which cannot be obtained by ground-based telescopes. Also, thanks to seeing free condition, "Hinode" continuously observes the magnetic field in the photosphere. From these experiences, we have learned following three important requirements for the future missions to solve "coronal heating" and "solar flare" problems;1) seamless and simultaneous observation covering all temperature regimes from the photosphere to the corona, 2) high spatial and temporal resolution to resolve elemental structures and to track their evolution, 3) plasma diagnostic capability to quantify the dynamics of elementary processes. Recently, solar physics community in Japan proposed Solar-C_EUVST mission which is intended to be launched in middle of 2020s. Further, next-generation instruments, such as Parker Solar Probe (PSP), the Daniel K. Inouye Solar Telescope (DKIST), and SUNRISE will appear even before Solar-C_EUVST. Several proposals, e.g., PhoENiX, are also appearing. We will discuss in this session what we should study for further understanding of solar physics from current observations and numerical simulations and what we must prepare before 2020s. We welcome participations and presentations especially from Solar Terrestrial Physics (STP) community.

[PEM19-P01] Onset Mechanism of the Largest Solar Flare in Solar Cycle 24

★Invited Papers

*Yumi Bamba[1,2], Satoshi Inoue[1], Shinsuke Imada[1], Kanya Kusano[1] (1.Institute for Space-Earth Environmental Research/Nagoya University, 2.Institute if Space and Astronautical Science/Japan Aerospace Exploration Agency)

[PEM19-P02] Infrequent Occurrence of Significant Linear Polarization in H-alpha Solar Flares

*Tomoko Kawate[1], Yoichiro Hanaoka[2] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.National Astronomical Observatory of Japan)

[PEM19-P03] Statistical study of solar flares simultaneously observed with RHESSI and Nobeyama Radioheliograph

*Satoshi Masuda[1], Sam Krucker[2,3], Stephen White[4] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.University of Applied Sciences Northwestern Switzerland, 3.University of California, Berkeley, 4.Air Force Research Laboratory)

[PEM19-P04] Microwave turn-over frequencies and emission temperatures for white-light solar flares

*Kosuke Tsuruda[1], Kyoko Watanabe[1], Satoshi Masuda[2], Säm Krucker[3] (1.National Defense Academy , 2.Institute for Space-Earth Environmental Research, Nagoya University, 3.University of Applied Sciences Northwestern Switzerland, UC Berkeley)

[PEM19-P05] Stellar flare of a close binary system monitored by the Hisaki satellite during the NICER-Hisaki Observing Campaign 2018-2019

*Tomoki Kimura[1], Wataru Iwakiri[2], Atsushi Yamazaki[3], Go Murakami[3], Fuminori Tsuchiya[4], Kazuo Yoshioka[5], Shin Toriumi[6], Hajime Kita[3], Masaki Kuwabara[3] (1.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 2.Faculty of Science and Engineering, Chuo University, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 4.Planetary Plasma

and Atmospheric Research Center, Tohoku University, 5.Department of Complexity Science and Engineering, University of Tokyo, 6.National Astronomical Observatory of Japan)

[PEM19-P06] Solar Neutron and Gamma-ray Observations with a 3U CubeSat

*Kazutaka Yamaoka[1], Hiroyasu Tajima[1], Kikuko Miyata[2], Takaya Inamori[2], Yoshinori Sasai[1], Kazuhiro Nakazawa[3], Satoshi Masuda[1], Koji Matsushita[4], Kazuya Itoh[4], Hiromitsu Takahashi[5], Kyoko Watanabe[6] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.School of Engineering, Nagoya University, 3.School of Science, Nagoya University, 4.Technical Center, Nagoya University, 5.School of Science, Hiroshima University, 6.National Defence Academy of Japan)

[PEM19-P07] Magnetic Flux Cancelation as the Buildup and Trigger Mechanism for CME-Producing Eruptions in two Small Active Regions

*Alphonse Sterling[1], Ronald L Moore[1,2], Navdeep K Panesar[1] (1.NASA/MSFC, 2.CSPAR, University of Alabama Huntsville)

[PEM19-P08] Estimation of turbulent pumping in the solar near-surface convection zone

*Haruhisa Iijima[1], Hideyuki Hotta[2], Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Graduate School of Science, Chiba University)

[PEM19-P09] Evaluation of the influence of the next solar cycle by sunspots using surface flux transport model

*Yusaku Watanabe[1], Shinsuke Imada[1], Haruhisa Iijima[1], Yoshizumi Miyoshi[1] (1.Institute for Space–Earth Environmental Research, Nagoya University)

[PEM19-P10] The image analysis of sunspot sketches in Dalton minimum(the early 1800s)

*SHOMA UNEME[1], Shinsuke Imada[1], Hisashi Hayakawa[2], Yoshizumi Miyoshi[1] (1.Nagoya University Institute for Space Earth for Enviornmental research, 2.Osaka University School of Letters)

[PEM19-P11] Observations of Photospheric Magnetic Structure below a Solar Dark Filament

*Takaaki Yokoyama[1], Yukio Katsukawa[2], Masumi Shimojo[2] (1.School of Science, The University of Tokyo, 2.National Astronomical Observatory of Japan)

[PEM19-P12] Science Target of Solar-C_EUVST Mission

*Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

Onset Mechanism of the Largest Solar Flare in Solar Cycle 24

*Yumi Bamba[1,2], Satoshi Inoue[1], Shinsuke Imada[1], Kanya Kusano[1]

1. Institute for Space-Earth Environmental Research/Nagoya University, 2. Institute if Space and Astronautical Science/Japan Aerospace Exploration Agency

Solar active region (AR) NOAA 12673, which appeared on the solar surface in September 2017, showed us amazing grows of magnetic field and produced numbers of flares including four X-class flares. We focused on the X2.2 and X9.3 flares that occurred while rapid growth of the AR on September 6, because latter the X9.3 flare caused increase of disturbances in ionosphere and magnetosphere. We aimed to understand the onset mechanism(s) of the X-class flares. Hence we analyzed the data obtained by Hinode and Solar Dynamics Observatory (SDO), and compared the analysis results to nonlinear force-free field (NLFFF), which is extrapolated from observed vector magnetic field.

We revealed that the key feature to trigger the X-class flares is the negative polarity region that emerged in the east in the AR and rapidly intrude into the positive polarity region. Highly sheared fields were located along the intruding negative field, and those were elongated and were pressed along with the intruding motion. Then the sheared fields were reconnected, and that could be a trigger of X-class flares. Hinode and SDO observed proxies of the magnetic reconnection, such as fast (over 100 km/s) down flow and brightening in the solar corona, over the intruding negative field approximately 2 hours before the X2.2 flare onset. The NLFFF has several small flux ropes that lying along the magnetic polarity inversion line. We found that a part of those flux ropes erupt in our magnetohydrodynamics (MHD) simulation. Therefore, a possibility that the intruding motion of the negative field would drive the flux rope to unstable state. This would cause the X2.2 small eruption. Following the X2.2 eruption, we further found that a new flux rope, which is larger and highly twisted, is formed by the reconnection between another small flux ropes, that shows dramatic eruption. We suggest that this eruption causes the X9.3 flare. In fact, the continuous intruding motion of negative field is observed after the X2.2 flare, therefore it would play an important role in producing the X9.3 flare.

From these results, we propose the scenario that the sequential X2.2 and X9.3 flares were triggered by push-mode-like magnetic reconnection corresponding to the intruding motion of the negative polarity field. We also discuss possibility of another triggering scenario such as emerging flux that has specific features of so-called the reversed shear type.

Keywords: Solar Flare, Hinode, Solar Dynamics Observatory, Flare Trigger, Solar Magnetic Field, Sunspot

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Infrequent Occurrence of Significant Linear Polarization in H-alpha Solar Flares

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We performed statistical and event studies of linear polarization in the H-alpha line during solar flares. The statistical study revealed that, among 71 H-alpha flares analyzed, including 64 GOES flares, only one event shows significant linear polarization signals. Such an infrequent occurrence of significant linear polarization in solar flares is consistent with the result by Bianda et al. (2005), who studied 30 flares and found no polarization signals. In the event showing the significant polarization, the maximum degree of linear polarization was 1.16±0.06%, and the average direction of the polarization deviated by -142.5±6.0 degrees from the solar north. The observed polarization degrees and the directions are consistent with the preceding reports. These strong linear polarization signals did not appear at major flare ribbons, nor did they correlate with either hard or soft X-ray emissions temporally or spatially. Instead they appeared at a minor flare kernel, which corresponds to one of the footpoints of a coronal loop. The active region caused coronal dimming after the soft X-ray peak. The observed flare show no direct evidence that the linear polarization is produced by high energy particles, which are often considered to generate the polarization. On the other hand, our study suggests the possibility that coronal mass ejections, which have been often observed in flares showing linear polarization signals, play an important role for exciting linear polarization at H-alpha flare kernels.

Keywords: Solar flare, Atomic Polarization, visible light

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Statistical study of solar flares simultaneously observed with RHESSI and Nobeyama Radioheliograph

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1. Institute for Space-Earth Environmental Research, Nagoya University, 2. University of Applied Sciences Northwestern Switzerland, 3. University of California, Berkeley, 4. Air Force Research Laboratory

Solar flares give us a unique opportunity to make spatially resolved observations to study magnetic energy release and particle acceleration in space plasmas. The most direct diagnostics of electron acceleration are provided through radio and hard X-ray observations where we observe synchrotron emissions in the GHz range and non-thermal bremsstrahlung emissions above typically 10 keV. The two leading solar dedicated observatories in these two wavelength ranges are the Nobeyama Radioheliograph (NoRH) and the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI).
We present a statistical study of 35 jointly observed big (>GOES M7) flares. Initial results reveal a linear correlation between the hard X-ray flux above 50 keV and the microwave fluxes at 17 and 34 GHz. This result indicates that the population of accelerated electrons emit both of hard X-rays and microwaves. The correlation is too good even if this is true. Because the mechanism of these two emissions (hard X-rays and microwaves) are much different. Hard X-rays are emitted by Bremsstrahlung and its intensity simply depends on the flux of the accelerated electrons precipitating into the chromosphere in the case that the thick-target model is valid. However, microwaves emitted by gyro-synchrotron are a little complex. The microwave source is observed at different location for flare by flare, i.e. near the looptop, at the footpoint region, and in between them. Footpoint region has much stronger magnetic field than the looptop region. Gyro-synchrotron emission is very sensitive to magnetic field strength. Though the microwave intensity may strongly depend on the source location, however, microwave intensity without any selection by source location shows a very good correlation with hard X-rays. Another puzzle is the energy spectrum of accelerated electrons. Roughly speaking, 50 keV hard X-rays are manly emitted by below 100 keV electrons. On the other hand, 17GHz and 34GHz microwaves are typically emitted by ~1 MeV electrons (it depends on the magnetic field strength of the emitting region). Typically accelerated electrons show a power-law spectrum with the power-law index 3 –6. The power-law index is different in flare by flare. When the number of 100 keV electrons is fixed, the number of 1 MeV electrons changes in 3 order of magnitudes with the change of the power-law index from 3 to 6. The microwave intensity is proportional to the number of ~1 MeV electrons. So roughly thinking, the ratio between hard X-rays and microwave intensity easily change with the change of the power-law index. Without considering the spectral information, we choose the events. However, still there is a very good correlation. This is also a hard puzzle.
In order to understand this too good correlation between hard X-ray and microwave intensity, we need further analyses such as source location of hard X-ray and microwaves, hard X-ray spectrum, photospheric magnetic field at the footpoint region, location of the flare on the solar disc, and so on.

Keywords: solar flare, particle acceleration, radio, hard X-ray

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Microwave turn-over frequencies and emission temperatures for white-light solar flares

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It is believed that the origin of white-light enhancement, which is usually associated with large solar flare, is accelerated non-thermal electrons. The relationship between emission measure and temperature of white-light flares (WLFs) supported the existence of strong magnetic field around the acceleration site (Watanabe et al., 2017). Although the field strength at the acceleration site cannot measure directly, it can be estimated by using the turn-over frequency of gyro-synchrotron emission in microwaves (Dulk 1985). Kitagawa (2015, master thesis) suggested the existence of strong magnetic field on WLFs because the turn-over frequencies of WLFs were higher than those of no white-light flares (NWLFs), by the microwave spectra observed with the Nobeyama Radio polarimeters (NoRP).

We performed a statistical analysis of microwave turn-over frequencies for >M3 class flares during the period from January 2011 to December 2017. We found 51 events which were simultaneously observed with white-light (*Hinode*/SOT and/or *SDO*/HMI) and microwave (NoRP), however, we couldn't find any difference in turn-over frequencies for WLF and NWLF. We thought this result might be due to the difference of the location (loop-top or foot-point) of the microwave source in each flare. Then we checked the location of microwave emission by comparing with images of *SDO*/AIA (193Å), Nobeyama Radio heliograph (NoRH, 17GHz), and/or RHESSI (30-80 keV). Finally we found 29 flares (WLF: 17 events, NWLF: 12 events) have a dominant microwave source around the loop-top. When we checked turn-over frequencies for these events, only 7 events (WLF: 4 events, NWLF: 3 events) have higher turn-over frequencies than 17 GHz, and no clear difference was found between WLF and NWLF. Because the turn-over frequency is determined by not only the field strength but also the electron density (Dulk 1985), we have to think about the variation of electron density for this study.
On the other hand, durations of flare were clearly differing in WLF and NWLF, and WLFs are well associated with impulsive flares (Watanabe et al., 2017). However, there are some impulsive flares that do not have any white-light enhancements. In order to check the effect of flare duration (impulsivity) for white-light emission, a statistical analysis of emission temperature for WLFs is one of the effective approaches. So we derive emission temperature from three-color continuum data of *Hinode*/SOT (red, green, and blue) for ~40 events (e.g. Watanabe et al., 2013; Kerr & Fletcher, 2014), and discuss the relationship with flare impulsivity.

Keywords: flares, radio radiation

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Stellar flare of a close binary system monitored by the Hisaki satellite during the NICER-Hisaki Observing Campaign 2018-2019

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Dynamics of stellar flare is still not well understood compared to that of the sun because of lack of continuous monitoring of distant stars in multiple wavelengths. Here we present a flare event at a close binary system, UX Arietis, monitored with the planetary extreme ultraviolet (EUV) space telescope Hisaki during the coordinated observing campaign with the NICER X-ray Telescope from late 2018 to early 2019. Time variability in the EUV spectrum of the binary was successfully monitored from the begging to the end of flare. Emission power at the EUV wavelengths peaked at ~6x10^24 W, which is comparable with that measured in the previous X-ray observations by e.g., the Advanced Satellite for Cosmology and Astrophysics (ASCA) (Gudel et al., 1999). The EUV spectrum showed emission lines of carbon, nitrogen, oxygen, and silicon ions. Electron temperature and density, emission measure, and ion balance were reduced from the emission lines by EUV spectral diagnostics. Dynamics of the stellar flare will be discussed based on comparison of the reduced plasma parameters with the X-ray spectrum measured with NICER.

Keywords: stellar flare, Hisaki

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Solar Neutron and Gamma-ray Observations with a 3U CubeSat

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Solar neutron observations are very important on understanding of particle acceleration mechanism in the Sun. However, previous ground-based observations with large area telescope (~10 m2)at high latitude are not sensitive to solar neutrons due to attenuation in the earth atomsphere and roughly 10 detection since its discovery in 1980 (Chupp et al. 1982). From space, the SEDA-AP instrument with much smaller area (100 cm^2) onboard the International Space Station (ISS) monitored solar neutrons including charged particles, and successfully detected more than 30 detection since its launch in 2009 (Muraki et al. 2014). Unfortunately the SEDA-AP operation was stopped on March 2018. To overcome situation for no mission dedicated for solar neutrons, we have designed and developed a solar neutron and gamma-ray detector for a 3U cubesat with a size of 30x10x10 cm. Actually we launched the 50-kg class ChubuSat-2 satellite for solar neutron observations on February 2016 (Yamaoka et al. 2016), and have now been modifying it to a 3U cubesat application. for the launch in 2021. The solar neutron and gamma-ray detector consists of multi-layered plastic scintillator bars, and GAGG(Ce) scintillator array, and both of them are read out with silicon photo-multipliers (Si PMs). More than 600 signals from Si PMs are processed by IDEAS ASICs. In this paper, we will describe scientific motivation, details of the detector and performance of its breadboard model (BBM).

Keywords: sun, Neutron, gamma-ray, detector, micro-satellite

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Magnetic Flux Cancelation as the Buildup and Trigger Mechanism for CME-Producing Eruptions in two Small Active Regions

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1. NASA/MSFC, 2. CSPAR, University of Alabama Huntsville

We follow two small, magnetically isolated CME-producing solar active regions (ARs) from the time of their emergence until several days later, when their core regions erupt to produce the CMEs. In both cases, magnetograms show: (a) following an initial period where the poles of the emerging regions separate from each other, the poles then reverse direction and start to retract inward; (b) during the retraction period, flux cancelation occurs along the main neutral line of the regions, (c) this cancelation builds the sheared core field/flux rope that eventually erupts to make the CME. In the two cases, respectively 30% and 50% of the maximum flux of the region cancels prior to the eruption. Recent studies indicate that solar coronal jets frequently result from small-scale filaments eruptions (Sterling et al. 2015), with those “minifilament” eruptions also being built up and triggered by cancelation of magnetic flux (Panesar et al. 2016). Together, the small-AR eruptions here and the coronal jet results suggest that isolated bipolar regions tend to erupt when some threshold fraction, perhaps in the range of 50%, of the region’s maximum flux has canceled. Our observed erupting filaments/flux ropes form at sites of flux cancelation, in agreement with previous observations. Thus, the recent finding that minifilaments that erupt to form jets also form via flux cancelation is further evidence that minifilaments are small-scale versions of the long-studied full-sized filaments. (Details are in Sterling et al. 2018, ApJ, 864, 68.) This work was supported by the NASA HGI Program, and the NASA/MSFC NPP program.

Keywords: Sun: Filaments, prominences, Sun: Magnetic fields, Sun: Flares, Sun: CMEs

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Estimation of turbulent pumping in the solar near-surface convection zone

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We estimate the turbulent transport coefficients of the mean field model of solar dynamo process using the three-dimensional radiation magnetohydrodynamic simulations. The number of studies has been devoted to investigate the mean field description of the solar dynamo process. Large uncertainty of this model comes from the turbulent transport coefficients like the turbulent diffusion, alpha effect, or turbulent pumping. Although various numerical and observational studies has been estimated the turbulent transport coefficients, very few studies focused on the near-surface values of the vertical transport coefficients. These vertical transport coefficients in the near-surface convection zone is important for characterizing the upper boundary of the solar dynamo models. In this study, we estimate the vertical transport coefficients such as the turbulent diffusion and pumping using the large-eddy numerical simulation. The realistic near-surface convection is modeled by the three-dimensional radiation magnetohydrodynamic simulations. In the presentation, we report the wavenumber dependence of the transport coefficients and suggest a suitable upper boundary condition of the solar dynamo models.

Keywords: Sun, Turbulence, Dynamo

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Evaluation of the influence of the next solar cycle by sunspots using surface flux transport model

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Predicting the next solar cycle and finding its schemes are a key for the long-term space weather research. Recent studies suggest that there is the correlation between polar magnetic field at the solar minimum and the next solar activity. Iijima et al. (2017) calculated the polar transport of the sunspots by using the surface flux transport model (SFT) and predicted the polar magnetic field at the solar minimum concluded that next solar cycle is weaker than the present. To evaluate their result, we have calculated the time evolution of the solar magnetic field for specific active region by SFT, and discussed the discrepancy between the model result and observations obtained by Helioseismic and Magnetic Imager (HMI). The peculiar example of the observation data is the active region AR12673 which occurred X9.3 solar flare on September 6, 2017 and played a role of weakening the negative magnetic field in the southern polar region. Meanwhile, AR12674 which appeared at the same time strengthened the positive magnetic field in the northern polar region, so we found the prediction result is different before and after the appearance of these active regions. Regarding the active regions after these, it is thought the influence is small because the transport to the polar region cannot be completed in time to the solar minimum. We confirmed reproducibility of polar transport in the model continuously using the actual magnetic field distribution from 2010 to the end of 2018 and the reproducibility 80 %, and found the activity of the next solar cycle is to be about 5 to 10 % stronger than present.

Keywords: Sun, Space weather, Magnetic fields

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The image analysis of sunspot sketches in Dalton minimum(the early 1800s)

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1. Nagoya University Institute for Space Earth for Enviornmental research, 2. Osaka University School of Letters

Solar activity changes periodically in 11 years. Because the solar activity is one of the main origins of the variability of the solar-terrestrial environment, it is important to predict the solar activity especially in the category of space weather study. It is known that the polar magnetic field at the solar minimum is closely correlated with the solar activity at the next solar activity. This correlation was confirmed by observing the current sun precisely. On the other hand, it is not clear whether there was a similar correlation in the past sun. Therefore, the aim of this study is to analyze the past sun spot sketch images to verify whether the polar field value at the solar minimum is also good correlation with the next solar activity. Especially, we focused on the Dalton minimum when sun spots were little in the early 1800s. We extracted latitude and longitude of sun spot from sketches in the early 1800 's. We will discuss the differences between the result obtained in this analysis and the characteristics of current sun. As a future plan, we calculate the surface magnetic flux transport model based on these obtained sun spot information and estimate the value of the polar magnetic field at the solar minimum of the Dalton minimum.

Keywords: sun, Dalton minimum, sketch, SFT

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Observations of Photospheric Magnetic Structure below a Solar Dark Filament

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The structure of the photospheric vector magnetic field below a dark filament on the Sun is studied using the observations of the Spectro-Polarimeter attached to the Solar Optical Telescope onboard Hinode. Special attention is paid to discriminate the two suggested models, a flux rope or a bent arcade. "Inverse-polarity" orientation is possible below the filament in a flux rope, whereas "normal-polarity" can appear in both models. We study a filament in active region NOAA 10930, which appeared on the solar disk during 2006 December. To know whether it is in the normal orientation or in the inverse one under 180-degree ambiguity of the transverse field, the center-to-limb variation is used for the solution under an assumption that the filament does not drastically change its magnetic structure during the passage. When the filament is near the east limb, we found that the line-of-site magnetic component below is positive, while it is negative near the west limb. This change of sign indicates that the horizontal photospheric field perpendicular to the polarity inversion line beneath the filament has an "inverse-polarity", that is indicating a flux-rope structure of the filament supporting field.

Keywords: Sun, filament, photosphere

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Science Target of Solar-C_EUVST Mission

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Solar-C EUVST (EUV High-Throughput Spectroscopic Telescope) is designed to comprehen- sively understand the energy and mass transfer from the solar surface to the solar corona and interplanetary space, and to investigate the elementary processes that take place universally in cosmic plasmas. The proposed mission is a fundamental step for answering how the plasma universe is created and evolves, and how the Sun influences the Earth and other planets in our solar system. The two primary science objectives for Solar-C EUVST are : I) Understand how fundamental processes lead to the formation of the solar atmosphere and the solar wind, II) Understand how the solar atmosphere becomes unstable, releasing the energy that drives solar flares and eruptions. Solar-C EUVST will, A) seamlessly observe all the temperature regimes of the solar atmosphere from the chromosphere to the corona at the same time, B) resolve elemental structures of the solar atmosphere with high spatial resolution and cadence to track their evolution, and C) obtain spectroscopic information on the dynamics of elementary pro- cesses taking place in the solar atmosphere. In this talk, we will discuss the science target of the Solar-C EUVST.

Keywords: Sun, corona, spectroscopy

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[J] Oral | P (Space and Planetary Sciences)：P-EM Solar-Terrestrial Sciences, Space Electromagnetism & Space Environment

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[P-EM19] Frontiers in the solar physics

convener:Shinsuke Imada(Institute for Space-Earth Environmental Research, Nagoya University), Takaaki Yokoyama(School of Science, University of Tokyo), Toshifumi Shimizu(Institute of Space and Astronautical Science, JAXA), Yukio Katsukawa(National Astronomical Observatory of Japan, National Institute of Natural Sciences), Chairperson:Shinsuke Imada

To date, we have three Japanese satellite missions to observe solar atmosphere, i.e., "Hinotori", "Yohkoh", and "Hinode", and revealed very dynamic nature of the solar atmosphere.These satellite observations allow us to see magnetic activities in the corona in X-ray, which cannot be obtained by ground-based telescopes. Also, thanks to seeing free condition, "Hinode" continuously observes the magnetic field in the photosphere. From these experiences, we have learned following three important requirements for the future missions to solve "coronal heating" and "solar flare" problems;1) seamless and simultaneous observation covering all temperature regimes from the photosphere to the corona, 2) high spatial and temporal resolution to resolve elemental structures and to track their evolution, 3) plasma diagnostic capability to quantify the dynamics of elementary processes. Recently, solar physics community in Japan proposed Solar-C_EUVST mission which is intended to be launched in middle of 2020s. Further, next-generation instruments, such as Parker Solar Probe (PSP), the Daniel K. Inouye Solar Telescope (DKIST), and SUNRISE will appear even before Solar-C_EUVST. Several proposals, e.g., PhoENiX, are also appearing. We will discuss in this session what we should study for further understanding of solar physics from current observations and numerical simulations and what we must prepare before 2020s. We welcome participations and presentations especially from Solar Terrestrial Physics (STP) community.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[PEM19-01] The Sun-Geospace connection: toward the 25th solar cycle

★Invited Papers

*Yoshizumi Miyoshi[1], Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[PEM19-02] Unsolved problems of the solar wind turbulence

★Invited Papers

*Munehito Shoda[1] (1.Graduate School of Science, University of Tokyo)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[PEM19-03] The Solar-C_EUVST Epsilon mission

*Toshifumi Shimizu[1] (1.Institute of Space and Astronautical Science, JAXA)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[PEM19-04] Advanced Observations of the Solar Atmosphere by a Balloon-Borne Telescope SUNRISE-3

*Yukio Katsukawa[1], Carlos Quintero Noda[2], Masahito Kubo[1], Hirohisa Hara[1], Toshifumi Shimizu[2] (1.National Astronomical Observatory of Japan, 2.ISAS/JAXA)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[PEM19-05] Radiation magnetohydrodynamic modeling of solar coronal dynamics

*Haruhisa Iijima[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[PEM19-06] Detection and energy derivation of nano-flares based on deep learning

*Toshiki Kawai[1], Shinsuke Imada[1] (1.Institute for Space-Earth Environmental Research, Nagoya University)

The Sun-Geospace connection: toward the 25th solar cycle

*Yoshizumi Miyoshi[1], Shinsuke Imada[1]

1. Institute for Space-Earth Environmental Research, Nagoya University

One of the major goals of solar-terrestrial physics is to understand how the transfer of Sun and solar wind energy into the Geospace and vice versa. In the last decade, there have been several flagship missions in Geospace; NASA/THEMIS, Van Allen Probes, and MMS, and JAXA/Arase, making important contributions to our understandings of how the Geospace responds on variations of Sun and solar wind. Solar atmosphere is also observed and monitored by modern satellite, such as Hinode, and Solar Dynamics Observatory. The present solar cycle (cycle 24) is one of the weakest cycles in these 100 years. Existing missions successfully observe several abnormal phenomena during weak solar cycle, such as extremely low-density solar wind, strong asymmetry for solar polar magnetic field, or relatively weak geomagnetic activities. For example, large flux enhancements of the outer belt associated with huge magnetic storms have not observed in cycle 24. Further, a lot of cycle prediction studies suggest that next solar cycle (cycle 25) is also as weak as cycle 24. There are also several preexisting and under-preparing missions which will be flagship missions during solar cycle 25. In this presentation, we briefly review highlights from these missions and discuss what subjects are important for the next decade, i.e, the 25th solar cycle to understand coupling process between Sun and Earth.

Keywords: Sun-Geospace Coupling, Cycle 25

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Unsolved problems of the solar wind turbulence

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The solar wind is characterized by fluctuations extending from MHD to kinetic scales and therefore is a unique laboratory of plasma turbulence. Despite a number of spacecraft missions for solar wind observation and numerical simulations, the solar wind turbulence involves several unsolved problems. These problems are related to problems in solar physics, including coronal heating and solar wind acceleration. In this talk, I will review unsolved problems of the solar wind turbulence and the latest understandings on them. Predictions for (and results of) Parker Solar Probe would also be discussed.

Keywords: MHD turbulence, MHD waves, solar wind acceleration

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The Solar-C_EUVST Epsilon mission

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1. Institute of Space and Astronautical Science, JAXA

Solar-C_EUVST (EUV High-Throughput Spectroscopic Telescope) is a solar physics mission which mission concept proposal has been selected as a candidate for JAXA competitive M-class missions in July 2018. As a fundamental step towards answering how the plasma universe is created and evolves, and how the Sun influences the Earth and other planets in our solar system, the proposed mission is designed to comprehensively understand how mass and energy are transferred throughout the solar atmosphere. The onboard science instrument EUVST is an EUV spectrometerwith slit-jaw imaging system that will simultaneously observe the solar atmosphere from the photosphere/chromosphere up to the corona with seamless temperature coverage, high spatial resolution, and high throughput for the first time. It is designed to provide an answer to the most fundamental questions in solar physics: how fundamental processes lead to the formation of the solar atmosphere and the solar wind, and how the solar atmosphere becomes unstable, releasing the energy that drives solar flares and eruptions. The mission will be launched and installed to a sun-synchronous polar orbit by a JAXA Epsilon vehicle in the first half of 2025. The paper will provide the overall description of the mission concept, science, and the latest status.

Keywords: Solar outer atmosphere, EUV Spectroscopy, New mission plan

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Advanced Observations of the Solar Atmosphere by a Balloon-Borne Telescope SUNRISE-3

*Yukio Katsukawa[1], Carlos Quintero Noda[2], Masahito Kubo[1], Hirohisa Hara[1], Toshifumi Shimizu[2]

1. National Astronomical Observatory of Japan, 2. ISAS/JAXA

The solar chromosphere interfacing the solar surface (i.e. photosphere) and the corona is not a simple intermediate atmospheric layer transmitting magnetic energy, but a region where strong non-linearity drives dynamic phenomena, such as turbulence, shocks, and jets. Because the dynamics are likely to be responsible for injection of non-thermal energies into the corona and the solar winds, the chromosphere is one of the most important targets in the solar and stellar physics. It is necessary to quantitatively observe 3D magnetic and velocity fields to cover the dynamics in the chromosphere together with energy generation in the photosphere. We plan to acquire high-quality 3D magnetic and velocity fields for the first time by the SUNRISE-3 balloon-borne solar telescope planned for 2021. We are building a high precision spectro-polarimeter called SCIP (SUNRISE Chromospheric Infrared spectro-Polarimeter) to be installed in SUNRISE-3 for precise spectro-polarimetric observation of near-IR spectral lines sensitive to magnetic fields in the photosphere and the chromosphere. To interpret the SUNRISE-3 data, we are developing numerical modeling of the dynamic phenomenon in the solar atmosphere as well as tools to interpret radiative transfer through the atmosphere. The goal is to understand the conversion process of magnetic energies in the astrophysical plasma based on spatially resolved observations of the Sun.

Keywords: Sun, Chromosphere, Corona, Magnetic field, Balloon observation

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Radiation magnetohydrodynamic modeling of solar coronal dynamics

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1. Institute for Space-Earth Environmental Research, Nagoya University

We present highly dynamic simulations of solar corona that exhibit intermittent heating and brightening based on the radiation magnetohydrodynamic model. The recent development of observational instruments allows us to access a large amount of remote-sensing image of the solar atmosphere. Because of the high nonlinearity of the solar atmosphere, the interpretation of the observational data is becoming more difficult. One approach to overcome this difficulty of the observational interpretation is to compare the observational data with synthesized realistic numerical simulations more directly. Realistic model of the solar corona should take into accout various physical processes like the radiative transfer, non-ideal equation of states, and thermal conduction. Our radiation magnetohydrodynamic model RAMENS is one of such solvers that can model the realistic solar dynamics from the upper convection zone to the corona. Recently, we further develop this code by including the semi-relativistic correction of the Alfven wave and thermal conduction to avoid severe time stepping near the active region. This new code allows us to simulate the highly dynamic solar corona within a moderate numerical cost. In the presentation, we will report our implementation of the semi-relativistic correction and present new energetic coronal simulations.

Keywords: Sun, Corona, Simulation

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Detection and energy derivation of nano-flares based on deep learning

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1. Institute for Space-Earth Environmental Research, Nagoya University

Coronal heating is one of the long-standing problems in solar physics. So far, two primary mechanisms have been proposed to explain how the corona is heated, namely small-scale magnetic reconnection and wave dissipation. To estimate the contribution of small-scale magnetic reconnection, so called nano-flares, to heat the corona is crucial to solve the coronal heating problem. The purpose of this study is to develop a method which can accurately detect nano-flares and estimate their energies. Firstly, we carry out one-dimensional hydrodynamic simulations of coronal loops heated by nano-flares which have wide range of energy ($10^{23} < E < 10^{27}$ erg). Secondly, we calculate the temporal variation of EUV and soft X-ray spectra of coronal loops from the simulation results by using CHIANTI atomic database. We perform these procedures more than 1,000 times with randomized flare energy and occurrence time to produce various datasets. Finally, we train a Deep Neural Network (DNN) by using these datasets to estimate the energy distribution and occurrence times of flares from soft X-ray observation. Moreover, we apply trained DNN to actual soft X-ray observations. As a result, we obtain reasonable occurrence times and energies of flares comparing another method which regards flare energy as change amount of thermal energy of the loop.

Keywords: deep learning, nano-flare

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[J] Oral | P (Space and Planetary Sciences)：P-AE Astronomy & Extrasolar Bodies

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 105 1F

[P-AE20] Exoplanet

convener:Masahiro Ikoma(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Norio Narita(University of Tokyo), Chairperson:Norio Narita(University of Tokyo), Masahiro Ikoma(The University of Tokyo)

Exoplanetary science, which began with the discovery of a hot Jupiter in 1995, has reached a major turning point by the discovery of countless super-Earths by the Kepler mission. More recently, planets that are similar in size to the Earth and also receive similar amounts of stellar radiation (namely, located in the so-called habitable zone) have been discovered around nearby stars such as Proxima Centauri and TRAPPIST-1. As a result, not only theoretical, but also observational studies on the atmospheres and surface environments of Earth-like exoplanets have been started. Moreover, the number of planets discovered around early-type and late-type stars has become large enough that the occurrence rate and orbital distribution of planets around a wide variety of host stars have become clear. Thus, new observational insights, which become the basis of pan-planet formation theory, are now gathering. While exoplanets have been mainly targeted for astronomy until recently, it can be said that earth planetary science is finally becoming a research field to make a central contribution. In this session, we aim to share cutting-edge research results in exoplanetary science which is in such a transition period.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PAE20-01] Gravitational Microlensing Surveys for Exoplanets

★Invited Papers

*Daisuke Suzuki[1] (1.Institute of Space and Astronautical Science / Japan Aerospace Exploration Agency)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PAE20-02] Doppler planet searches targeting stars in solar neighborhood

★Invited Papers

*Bunei Sato[1] (1.Tokyo Institute of Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PAE20-03] Development of MuSCAT3 for ground-based follow-up observations of TESS candidate exoplanets

*Norio Narita[1,2,3], Akihiko Fukui[2], Masahiro Ikoma[2], Motohide Tamura[1,2], Nobuhiko Kusakabe[1], Mayuko Mori[2], Tomoyasu Yamamuro[4] (1.Astrobiology Center, 2.University of Tokyo, 3.JST, 4.OptCraft)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PAE20-04] Effect of metallicity and eddy diffusion on transmission spectra of hazy exoplanet atmospheres

*Yui Kawashima[1], Masahiro Ikoma[2] (1.SRON Netherlands Institute for Space Research, 2.The University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PAE20-05] Mineral clouds of fluffy aggregates: how they form in exoplanetary atmospheres and influence transmission spectra

*Kazumasa Ohno[1], Satoshi Okuzumi[1], Ryo Tazaki[2] (1.Department of Earth and Planetary Science, Tokyo Institute of Technology, 2.Astronomical Institute, Tohoku University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PAE20-06] Orbital Architecture of Planetary Systems Formed by Giant Impacts

★Invited Papers

*Eiichiro Kokubo[1] (1.Division of Theoretical Astronomy, National Astronomical Observatory of Japan)

Gravitational Microlensing Surveys for Exoplanets

*Daisuke Suzuki[1]

1. Institute of Space and Astronautical Science / Japan Aerospace Exploration Agency

Gravitational microlensing can detect cold planets beyond the snow line. It is sensitive to the planets down to the Earth mass. Thus, it is only microlensing among the current exoplanet detection methods that can probe the outer planets orbiting other stars. In this talk, we present the recent microlensing statistical study which finds a disagreement between the observed planet mass-ratio function and the prediction from the population synthesis models based on the core accretion model. The models predict 7 - 10 times fewer planets at mass-ratios of $10^{-4} < q < 10^{-3}$ than found by the microlensing observations. This implies that the formation of gas giants may involve more complicated processes than assumed by the standard core accretion theory. Or, it implies that the planet formation process may vary significantly as a function of host star mass, because the population synthesis models have been calibrated for planets around solar-type stars while microlensing observations are biased toward lower-mass stars.

We also present recent planet discoveries with mass constraint and/or measurement by using the space-based observations or 10m class telescopes. Finally, we introduce future, infrared microlensing surveys, such as the PRIME (PRime-focus Infrared Microlensing Experiment) project and NASA’s WFIRST (Wide Field Infrared Survey Telescope) microlensing survey.

Keywords: Exoplanets, Gravitational Microlensing

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Doppler planet searches targeting stars in solar neighborhood

*Bunei Sato[1]

1. Tokyo Institute of Technology

A precise Doppler measurement is one of the powerful techniques to detect planets orbiting stars. The technique is applicable to the detection of planets with a wide range of orbital parameters, such as semimajor axis and eccentricity, mass, and host stars. The planets detected by the Doppler surveys can thus help us to gain a general understanding of planet formation and evolution. Furthermore, given the high detection efficiency of planets of the Doppler technique compared to transit ones, it is highly useful to search for planets around stars in solar neighborhood.

We have been conducting Doppler planets searches for planets around nearby giant stars, that is evolved intermediate-mass stars, for about 20 years with 188cm telescope and High Dispersion Echelle Spectrograph (HIDES) of Okayama observatory. We have also started intensive Doppler monitoring of nearby bright solar-type stars at Okayama aiming to explore low-mass planets in their habitable zones. Thanks to refurbishment of the HIDES last year, we can now achieve a Doppler precision better than 1 m/s. In this February, a new planet search program targeting nearby low-mass M-type dwarfs was launched with use of the new InfraRed Doppler instrument (IRD) of Subaru 8.2m telescope. The program aims at detecting earth-mass planets in their habitable zones as well as uncovering population of planets around them. Here we report the latest results from these planet-search programs and discuss future prospects.

Keywords: Doppler technique, nearby stars, habitable zone, earth-mass planets

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Development of MuSCAT3 for ground-based follow-up observations of TESS candidate exoplanets

*Norio Narita[1,2,3], Akihiko Fukui[2], Masahiro Ikoma[2], Motohide Tamura[1,2], Nobuhiko Kusakabe[1], Mayuko Mori[2], Tomoyasu Yamamuro[4]

1. Astrobiology Center, 2. University of Tokyo, 3. JST, 4. OptCraft

NASA's Transiting Exoplanet Survey Satellite (TESS), launched on 2018 April 18, will start its survey for northern sky from 2019 summer. TESS is expected to find a large number of candidate transiting exoplanets after 2019 autumn.
Toward the start of the northern sky survey, we are now developing a 4-color simultaneous camera MuSCAT3 for the 1.2m telescope located in the Fred Lawrence Whipple Observatory on Mt. Hopkins in Arizona, USA. This is a successor of existing multi-color simultaneous cameras MuSCAT1/2 on the 188cm telescope in Okayama, Japan and on the 1.52m telescope in Tenerife, Canaries, Spain. MuSCAT3 will work with MuSCAT1/2 and enable 24-hour multi-color simultaneous imaging/photometry in the northern hemisphere. This is the one and only multi-color transit observation network in the world as of 2019. Thereby, we can conduct intensive ground-based follow-up observations rapidly after TESS's data releases, and can lead in discriminating and finding true interesting transiting planets in the world.
In this presentation, we will introduce the specifications of MuSCAT3 and the 1.2m telescope, and present prospects of MuSCAT3 development and synergies with TESS and MuSCAT1/2.

Keywords: exoplanets, transit, instrument, TESS

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Effect of metallicity and eddy diffusion on transmission spectra of hazy exoplanet atmospheres

*Yui Kawashima[1], Masahiro Ikoma[2]

1. SRON Netherlands Institute for Space Research, 2. The University of Tokyo

Recently, properties of exoplanet atmospheres have been constrained via multi-wavelength transit observation, which measures an apparent decrease in stellar brightness during planetary transit in front of its host star (called transit depth). Sets of transit depths so far measured at different wavelengths (called transmission spectra) for some exoplanets are featureless or flat, inferring the existence of haze particles in the atmospheres. Previous studies that addressed theoretical modeling of transmission spectra of hydrogen-dominated atmospheres with haze used some assumed distribution and size of haze particles. In Kawashima & Ikoma (2018), we developed new photochemical and microphysical models of the creation, growth, and settling of haze particles for deriving their size and number-density distributions in close-in warm (< 1000 K) exoplanet atmospheres.

In this study, we explore the dependence of the production rate of haze and the resultant transmission spectra on metallicity and eddy diffusion coefficient. We find that the photodissociation rates of the hydrocarbons, which are related to the haze monomer production rate, are basically smaller for higher metallicity in spite of their increased abundances. This is because of the enhanced photon-shielding effect by the major photon absorbers, H_2O, CO, CO_2, and O_2, existing at higher altitudes than the hydrocarbons. Thus, the transmission spectrum for higher metallicity atmosphere is less affected by haze. We also find that the efficient eddy diffusion yields a steep Rayleigh-scattering slope in the optical and more prominent molecular-absorption features, which is the dependence opposite of condensation clouds.

Keywords: Atmospheres, Transmission spectra, Haze, Metallicity, Eddy diffusion

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Mineral clouds of fluffy aggregates: how they form in exoplanetary atmospheres and influence transmission spectra

*Kazumasa Ohno[1], Satoshi Okuzumi[1], Ryo Tazaki[2]

1. Department of Earth and Planetary Science, Tokyo Institute of Technology, 2. Astronomical Institute, Tohoku University

Observations of transmission spectra have suggested ubiquity of high-altitude clouds in exoplanetary atmospheres. Recent theoretical studies have examined the formation of high-altitude clouds; however, they usually need to assume vigorous vertical mixing to explain the observations, which is orders of magnitude stronger than that suggested from general circulation models. The discrepancy might be caused by an assumption of the compact spheres for cloud particles adopted in previous studies. Because the hot environment of exoplanets leads to the formation of mineral condensates, they potentially grow into fluffy aggregates with very low sedimentation velocity that can be easily transported to high altitude. In this study, we investigate the influences of the particle porosity on vertical profiles of the clouds using a microphysical model taking into account the vertical transport, particle growth, and porosity evolution of cloud particles. We will demonstrate that the particle density can be lower than the material density by 2–3 orders of magnitude. As a result, the vertical extent of the clouds is potentially much larger than that expected in previous studies. We also calculate synthetic transmission spectra with fluffy-aggregate clouds. The fluffy-aggregate clouds largely obscure molecular signatures in the spectra and produce a characteristic spectral slope in visible to near-infrared wavelength. Finally, we compare the synthetic spectra with the transmission spectrum of GJ1214b, a super-Earth suggested to have clouds at ~0.01mbar in pressure, and find that the observed spectra can be explained by the mineral cloud of fluffy aggregates if atmospheric metallicity is higher than 100 times solar abundance. The predicted high atmospheric metallicity might encapsulate information about the formation process of GJ1214b.

Keywords: Exoplanet, Cloud, Transmission spectrum

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Orbital Architecture of Planetary Systems Formed by Giant Impacts

*Eiichiro Kokubo[1]

1. Division of Theoretical Astronomy, National Astronomical Observatory of Japan

In the standard scenario, the final stage of terrestrial planet formation is giant impacts among protoplanets. In this stage protoplanets gravitationally scatter each other and collide until the system reaches a stable configuration. We investigate the final orbital architecture of planetary systems realized by this process by *N*-body simulation. We find that the ratio between the physical and Hill radii of protoplanets determines the system architecture and it becomes compact and dynamically cold as the ratio increases. We also compare the results with the oribital architecture of exoplanetary systems.

Keywords: terrestrial planets, giant impacts

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[J] Oral | P (Space and Planetary Sciences)：P-AE Astronomy & Extrasolar Bodies

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 105 1F

[P-AE20] Exoplanet

convener:Masahiro Ikoma(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Norio Narita(University of Tokyo), Chairperson:Masahiro Ikoma(The University of Tokyo), Norio Narita(University of Tokyo)

Exoplanetary science, which began with the discovery of a hot Jupiter in 1995, has reached a major turning point by the discovery of countless super-Earths by the Kepler mission. More recently, planets that are similar in size to the Earth and also receive similar amounts of stellar radiation (namely, located in the so-called habitable zone) have been discovered around nearby stars such as Proxima Centauri and TRAPPIST-1. As a result, not only theoretical, but also observational studies on the atmospheres and surface environments of Earth-like exoplanets have been started. Moreover, the number of planets discovered around early-type and late-type stars has become large enough that the occurrence rate and orbital distribution of planets around a wide variety of host stars have become clear. Thus, new observational insights, which become the basis of pan-planet formation theory, are now gathering. While exoplanets have been mainly targeted for astronomy until recently, it can be said that earth planetary science is finally becoming a research field to make a central contribution. In this session, we aim to share cutting-edge research results in exoplanetary science which is in such a transition period.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PAE20-07] Thermal convection in the mantle of super-Earths

★Invited Papers

*Takehiro Miyagoshi[1], Masanori Kameyama[2], Masaki Ogawa[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Ehime University, 3.University of Tokyo)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PAE20-08] Atmospheric escape from M-dwarf exoplanets and implications for habitability

*Chuanfei Dong[1] (1.Princeton University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PAE20-09] Theoretical emission spectra of hot rocky super-Earths: Lack of alkali metals due to atmospheric escape

*Yuichi Ito[1,2], Masahiro Ikoma[2] (1.Department of Cosmosciences, Graduate school of Science, Hokkaido University, 2.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PAE20-10] Hot Rocky Super-Earths atmospheres, a revision of gas phase metal chemistry and the relevance of reverse chemistry

*Sebastian Danielache[1,2], Takahashi Yuta[1], Miguel Yamila[3], Simoncini Eugenio[4], Grassi Tommaso[5] (1.Department of Materials & Life Sciences, Faculty of Science & Technology, Sophia University, 2.Tokyo Institute of Technology, Earth-Life Institute , 3.Leiden Observatory, Leiden University, 4.Simoncini Telai Gambassi Terme, 5.University Observatory Munich, Ludwig-Maximilians-University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PAE20-11] A Climate of tidally locked terrestrial exoplanets

*Takanori Kodama[1] (1.University of Bordeaux)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PAE20-12] Current status of WSO-UV/UVSPEX for discovery of Earth-like planets

*Shingo Kameda[1], Osada Naoya[1], Takanori Kodama[2], Go Murakami[3], Keigo Enya[3], Masahiro Ikoma[4], Norio Narita[5], Naoki Terada[6], Hitoshi Fujiwara[7] (1.School of Science, Rikkyo University, 2.University of

Bordeaux, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency,
4.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo,
5.National Astronomical Observatory of Japan, 6.Graduate School of Science, Tohoku University,
7.Faculty of Science and Technology, Seikei University)

Thermal convection in the mantle of super-Earths

*Takehiro Miyagoshi[1], Masanori Kameyama[2], Masaki Ogawa[3]

1. Japan Agency for Marine-Earth Science and Technology, 2. Ehime University, 3. University of Tokyo

Thermal convection in the mantle of super-Earths is one of the most important issues to understand their thermal history and surface environment. It is also linked to the habitability of planets because it controls the plate motion, material circulation, the vigor of core convection and planetary dynamos, and so on.

One of the most important differences between the Earth’s and super-Earth’s interior is that there is a strong adiabatic compression effect in super-Earths. Usually, this effect is ignored in modelling the dynamics in the mantle of the Earth because the effect is small in the Earth. However, this effect becomes strong as the size of planets increases so it cannot be ignored in large planets. In this paper we introduce our results of numerical simulation studies of thermal convection in super-Earths (up to ten times the Earth’s mass) with this effect (Miyagoshi et al., 2014; 2015; 2017; 2018). We also take account for high Rayleigh number which is relevant for super-Earths, and temperature-dependent viscosity contrast and depth-dependent thermal expansion coefficient.

We found that the activity of ascending hot plumes is lowered as the planetary size increases. In contrast, the activity of cold plumes is not lowered even in large planets. The efficiency of heat transport by thermal convection is significantly lowered compared with the results with Boussinesq approximation in which there is no adiabatic compression and which is often used in models for the Earth. We also found the convective regime diagram in massive super-Earths (ten times the Earth’s mass) and how the threshold between stagnant-lid regime and weak-viscosity-contrast regime is determined.

We also found the effects of adiabatic compression become substantial when the planetary mass exceeds about 4 times the Earth’s mass. The plate thickness increases and the convective velocity is almost constant as the planetary mass increases. These results are in a striking contrast with earlier predictions that are made by the Boussinesq approximation models.

We also explored the thermal evolution process in massive super-Earths (ten times the Earth’s mass). At initial the shallow mantle of the planet is hotter than expected from the adiabatic extrapolation from the deep mantle, as expected when the planet is formed from giant impact. We found that the influences of an initial temperature distribution continue extremely long in massive super-Earths. In our case, transient layered convection caused by the initial temperature distribution continues for as long as several to ten billion years before it yields to a whole layer convection.

Our results suggest that the tectonic activities such as plate motion and hot spot volcanisms hardly occur as planetary size increases. The planetary magnetic field is expected to be not so strong in massive super-Earths because of the weak efficiency of heat transport by the mantle convection. In addition, especially in massive super-Earths, special attention for the extremely long transient stage which is affected by the initial temperature distribution is necessary to discuss details of its interior and tectonic activities.

Keywords: super-Earths, mantle convection, adiabatic compression

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Atmospheric escape from M-dwarf exoplanets and implications for habitability

*Chuanfei Dong[1]

1. Princeton University

In the last two decades, the field of exoplanets has witnessed a tremendous creative surge. Research in exoplanets now encompasses a wide range of fields ranging from astrophysics to heliophysics and climate science. One of the primary objectives of studying exoplanets is to determine the criteria for habitability, and whether certain exoplanets meet these requirements. The classical definition of the Habitable Zone (HZ) is the region around a star where liquid water can exist on the planetary surface given sufficient atmospheric pressure. However, this definition largely ignores the impact of the stellar wind and stellar magnetic activity on the erosion of an exoplanet's atmosphere. Amongst the many factors that determine habitability, understanding the mechanisms of atmospheric loss is of paramount importance.

We will discuss the impact of exoplanetary space weather on the long-term climate evolution and habitability, which offers fresh insights concerning the habitability of exoplanets, especially those orbiting M-dwarfs, such as Proxima b and the TRAPPIST-1 planets. I will focus on a wide range of atmospheric compositions, ranging from exo-Venus candidates to ocean worlds; the latter being a unique class of planets with water-rich surfaces and atmospheres that do not currently exist in our Solar system. For each of these cases, we will demonstrate the importance of the exoplanetary space weather on atmospheric ion loss and habitability.

Keywords: atmospheric escape, planetary habitability, M-dwarf exoplanets, stellar wind and magnetic activity, Proxima b, the TRAPPIST-1 planets

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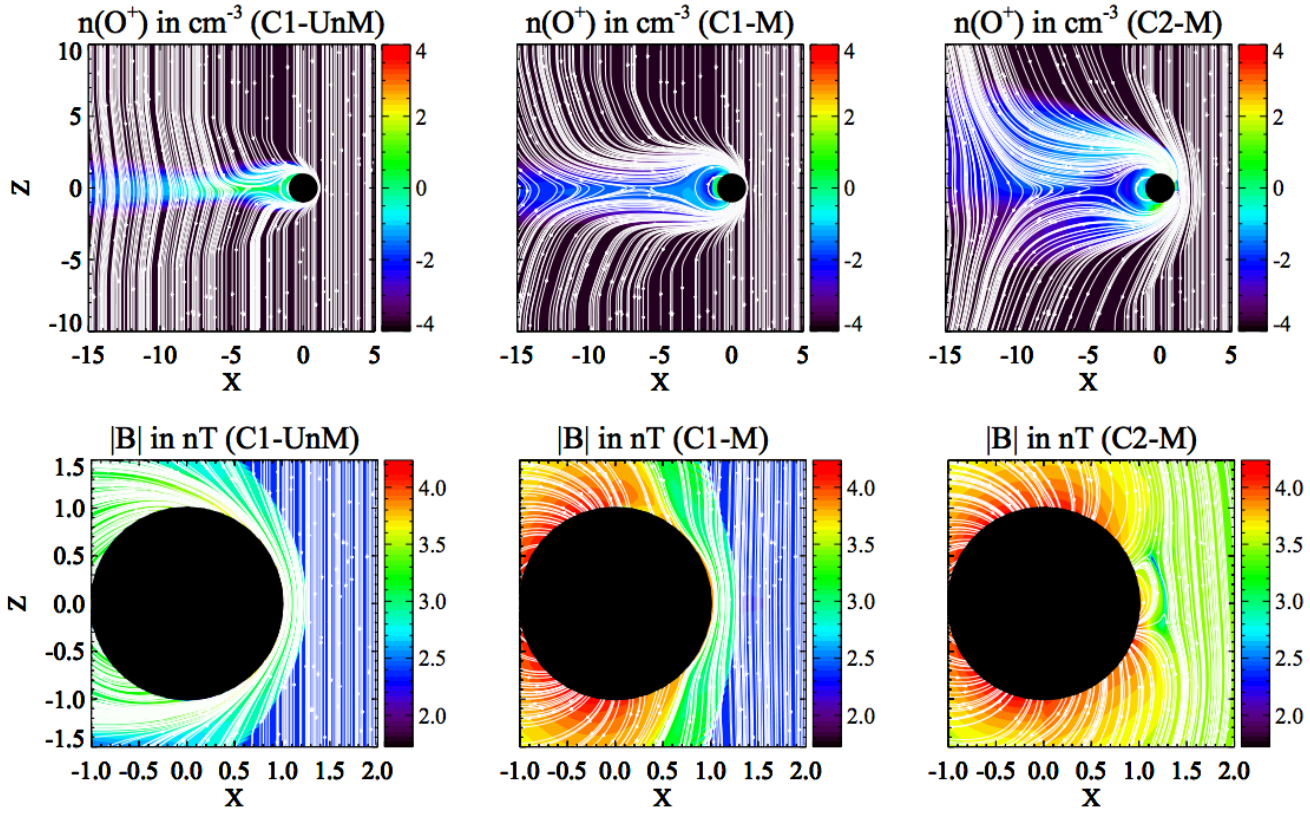

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Theoretical emission spectra of hot rocky super-Earths: Lack of alkali metals due to atmospheric escape

*Yuichi Ito[1,2], Masahiro Ikoma[2]

1. Department of Cosmosciences, Graduate school of Science, Hokkaido University, 2. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

Until today, over 1000 exoplanets whose radii are less than 2 Earth radii have been discovered. About 50% of those planets have radiative equilibrium temperatures high enough to melt and vaporize rock. Thus, if rocky like CoRoT-7b, they likely have atmospheres composed of rocky materials (e.g., Schaefer & Fegley 2009, Ito et al.2015). We call such a rocky vapor atmosphere a mineral atmosphere in this study. In addition, previous studies showed that atmospheric loss processes such as atmospheric escape cause selective depletion of Na and K in the atmosphere and magma ocean, because of the high-volatility and low abundance of Na and K in rocks. Also, our new 1-D hydrodynamic model of the highly UV-irradiated mineral atmosphere (Ito & Ikoma, in prep) suggests that the hydrodynamic escape is massive enough to remove completely Na and K during the early stage of the host star. Thus, the detection of a mineral atmosphere would provide definitive evidence that the planet is rocky. Moreover, identifying the mineral atmosphere composition, especially the presence or absence of Na and K, would give constraints on the magma composition which could trace not only the interior but evolution of planets.

In this study, we focus on the temperature-pressure structure and detectability for emission spectra of the mineral atmosphere in hydrostatic equilibrium on a hot rocky super-Earth. Also, we investigate the impact of the selective depletion of Na and K on the thermal structure and emission spectra. In order to investigate it, we use the hydrostatic/radiative/chemical equilibrium atmospheric model for mineral atmospheres (Ito et al. 2015) which calculates the gas-melt equilibrium composition of the mineral atmosphere, vertical thermal structure and secondary eclipse depths. We show our results for higher planetary equilibrium temperature (2500, 3000K) such as CoRoT-7 b and Kepler-10 b. We find that the thermal inversion structure of the mineral atmosphere without Na and K is hotter than that of the atmosphere with Na and K. This is mainly because the atmosphere inefficiently emits photons in visible wavelength region due to the lack of Na and K. Our feasibility assessment demonstrates that identification of mineral atmospheres with and without Na and K on hot rocky super-Earths in secondary transit is possible via observation from space telescopes.

Keywords: Exoplanet, Atmosphere, Terrestrial planet

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Hot Rocky Super-Earths atmospheres, a revision of gas phase metal chemistry and the relevance of reverse chemistry

*Sebastian Danielache[1,2], Takahashi Yuta[1], Miguel Yamila[3], Simoncini Eugenio[4], Grassi Tommaso[5]

1. Department of Materials & Life Sciences, Faculty of Science & Technology, Sophia University, 2. Tokyo Institute of Technology, Earth-Life Institute , 3. Leiden Observatory, Leiden University, 4. Simoncini Telai Gambassi Terme, 5. University Observatory Munich, Ludwig-Maximilians-University

There are approximately 2600 reported exoplanets. Among these celestial bodies there is a class of super-Hearts with an orbit smaller than Mercury (0.387 AU) know as Hot Rocky Super-Earths (HRSE). The proximity of this rocky type of planets to their parent start means that their surface can be similar to Bulk Silicate Earth (BSE) at high temperatures. Currently, there are few attempts to estimate the atmospheric composition and chemistry of a HRSE.

Keywords: Hot Rocky Super-Earths, Atmospheric Chemistry

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A Climate of tidally locked terrestrial exoplanets

*Takanori Kodama[1]

1. University of Bordeaux

Most of the studies for habitable planets focus on to determine the boundary of the habitable zone. From observation of exoplanet, planets with mass between the Earth and super-Earth around low-temperature star have been discussed. The rotation of such a planet is locked due to the tidal effect from the central star because they locate near the central star.

On most of the previous studies, they used one-dimensional climate models and estimated the habitable zone assuming water-rich planets, like the Earth. Recently, studies of habitable climate using a three-dimensional climate model have begun. They show that the habitable zone estimated by 3D GCM (three-dimensional general circulation model) is greatly different from that by the 1D climate model. The most important difference is the distribution of cloud in the planetary atmosphere. A terrestrial planet with liquid water on the surface around a low-temperature star has clouds in high altitude around the sub-stellar point, leading higher albedo. As a result, it can maintain a warmer climate if it is located out of the habitable zone estimated by a 1D climate model. However, when the rotation period of a planet is short enough, the pattern of the circulation changes to the super-rotation. In this case, no such clouds are formed around the sub-stellar point.

I investigate the pattern of the circulation and habitability for TRAPPIST-1 d and Proxima Centauri b. Additionally, I also investigate the effect of the distribution of water on the planetary surface on the formation of cloud.

Keywords: Habitable exoplanets

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Current status of WSO-UV/UVSPEX for discovery of Earth-like planets

*Shingo Kameda[1], Osada Naoya[1], Takanori Kodama[2], Go Murakami[3], Keigo Enya[3], Masahiro Ikoma[4], Norio Narita[5], Naoki Terada[6], Hitoshi Fujiwara[7]

1. School of Science, Rikkyo University, 2. University of Bordeaux, 3. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 4. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 5. National Astronomical Observatory of Japan, 6. Graduate School of Science, Tohoku University, 7. Faculty of Science and Technology, Seikei University

The World Space Observatory for Ultraviolet (WSO-UV) is an orbital optical telescope with a 1.7-m diameter primary mirror currently under development. The WSO-UV is aimed to operate in the 115- to 310-nm UV spectral range. Its two major science instruments are UV spectrographs and UV imaging field cameras with filter wheels. The WSO-UV project is currently in the implementation phase, with a tentative launch date in 2023. As designed, the telescope field of view in the focal plane is not fully occupied by instruments. Recently, two additional instruments devoted to exoplanets have been proposed for WSO-UV, which are the focus of this paper. UVSPEX, a UV-spectrograph for exoplanets, aims to determine atomic hydrogen and oxygen abundance in the exospheres of terrestrial exoplanets. The spectral range is 115 to 130 nm, which enables simultaneous measurement of hydrogen and oxygen emission intensities during an exoplanet transit. A study of exosphere transit photometric curves can help differentiate among different types of rocky planets. The exospheric temper- ature of an Earth-like planet is much higher than that of a Venus-like planet because of the low mixing ratio of the dominant coolant (CO2) in the upper atmosphere of the former, which causes a large difference in transit depth at the oxygen emission line. Thus, whether the terrestrial exoplanet is Earth-like, Venus-like, or other can be determined.

Keywords: exoplanet, terrestrial planet, upper atmosphere

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[J] Poster | P (Space and Planetary Sciences)：P-AE Astronomy & Extrasolar Bodies

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_4

[P-AE20] Exoplanet

convener:Masahiro Ikoma(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Norio Narita(University of Tokyo)

Exoplanetary science, which began with the discovery of a hot Jupiter in 1995, has reached a major turning point by the discovery of countless super-Earths by the Kepler mission. More recently, planets that are similar in size to the Earth and also receive similar amounts of stellar radiation (namely, located in the so-called habitable zone) have been discovered around nearby stars such as Proxima Centauri and TRAPPIST-1. As a result, not only theoretical, but also observational studies on the atmospheres and surface environments of Earth-like exoplanets have been started. Moreover, the number of planets discovered around early-type and late-type stars has become large enough that the occurrence rate and orbital distribution of planets around a wide variety of host stars have become clear. Thus, new observational insights, which become the basis of pan-planet formation theory, are now gathering. While exoplanets have been mainly targeted for astronomy until recently, it can be said that earth planetary science is finally becoming a research field to make a central contribution. In this session, we aim to share cutting-edge research results in exoplanetary science which is in such a transition period.

[PAE20-P01] An interpretation of exoplanet masses and orbital radii with a theoretical model of gas giant formation

*Kiyoka Murase[1], Hidekazu Tanaka[1] (1.TOHOKU UNIVERSITY)

[PAE20-P02] Impact of resonance trapping of planetesimals during planetary migration on metallicities of close-in gas giants

*Sho Shibata[1], Masahiro Ikoma[1] (1.Graduate School of Science, The University of Tokyo)

[PAE20-P03] Theoretical modeling of hydrogen line emission from accreting gas giants: comparison with observations of LkCa15b and PDS70b

*Yuhiko Aoyama[1], Masahiro Ikoma[1], Gabriel-Dominique Marleau[2], Christoph Mordasini[3] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Institute for Astronomy and Astrophysics, Eberhard Karls University of Tubingen, 3.Physics Institute, University of Bern)

[PAE20-P04] Design of a Lyman alpha telescope LAICA2 for exoplanetary exploration

*Toru Muraoka[1], Go Murakami[2], Shingo Kameda[1] (1.Rikkyo University, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

[PAE20-P05] Numerical experiments on thermal convection of highly compressible fluids: Influences for mantle convection of super-Earths

*Masanori Kameyama[1,2] (1.Geodynamics Research Center, Ehime University, 2.Japan Agency for Marine-Earth Science and Technology)

[PAE20-P06] Impact of Stellar Superflares on Planetary Habitability

*Yosuke Alexandre Yamashiki[1], Hiroyuki Maehara[2], Vladimir Airapetian[5], Yuta Notsu[3], Tatsuhiko Sato[4], Shota Notsu[3], Ryusuke Kuroki[1], keiya murashima[8], Hiroaki Sato[7], Kosuke Namekata[3], Takanori Sasaki[3], Thomas Scott[9], Hina Bando[3], Subaru Nashimoto[8], Fuka Takagi[6], Cassandra Ling[1], Daisaku Nogami[3], Kazunari Shibata[10] (1.Earth & Planetary Water Resources Assessment Laboratory Graduate School of Advanced Integrated Studies in Human Survivability Kyoto University, 2.National Astronomical Observatory of Japan, 3.Department of Astronomy, Kyoto University, 4.Japan Atomic Energy Agency, 5.NASA / GSFC, 6.Faculty of Agriculture, Kyoto University, 7.Faculty of Engineering, Kyoto University,

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[PAE20-P07] Studies of atmospheric structure in new very-hot Jupiter with high-resolution transmission spectroscopy

*Kiyoe Kawauchi[1], Bun'ei Sato[1], Norio Narita[2], Teruyuki Hirano[1], Yui Kawashima[3] (1.Tokyo Institute of Technology, 2.Tokyo University, 3.SRON - Netherlands Institute for Space Research)

[PAE20-P08] Doppler Tomographic Analysis for the Planetary Orbital Precession of WASP-33b

*Noriharu Watanabe[1], Norio Narita[2], Marshall C. Johnson[3] (1.The Graduate University for Advanced Studies, 2.The University of Tokyo, 3.The Ohio State University)

[PAE20-P09] TESS Follow-up Observation with IRSF/SIRIUS

*Mayuko Mori[1], Norio Narita[1,2], Jerome Pitogo de Leon[1], Taku Nishiumi[3], Akihiko Fukui[1], Motohide Tamura[1,2], Nobuhiko Kusakabe[2], Kumiko Morihana[4] (1.The University of Tokyo, 2.Astrobiology Center, NINS, 3.Kyoto Sangyo University, 4.Nagoya University)

[PAE20-P10] Status of the Multi-band Cameras for Transiting Exoplanets MuSCAT1,2 and New Results in 2018

*Akihiko Fukui[1], Norio Narita[2], Nobuhiko Kusakabe[2], Motohide Tamura[2,1], Kiyoe Kawauchi[1], John Livingston[1], Jerome de Leon[1], Noriharu Watanabe[3], Yuka Terada[1], Mayuko Mori[1], Taku Nishiumi[4] (1.The University of Tokyo, 2.Astrobiology Center, 3.SOKENDAI, 4.Kyoto Sangyo University)

An interpretation of exoplanet masses and orbital radii with a theoretical model of gas giant formation

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About 4000 exoplanets have been detected and their statistical properties such as mass and orbital distributions become clear. However, the origin of these distributions is still uncertain. In this study, applying a recent core accretion model to data ofexoplanets, we clarify whether it is possible to explain the observed distributions ofmasses and orbital radii, and in what protoplanetary disk they can be explain.
We adopt the following theoretical model of gas giant formation in this study. We use the model of Tanigawa & Tanaka (2016) for the mass growth rate (i.e., the gasaccretion rate onto a planet) and the latest model of Kanagawa et al.(2018) for the planetary migration speed. Those are reliable because of their consistency with severalresults of hydrodynamic simulations. For simplification, interactions among multiple planets are ignored. Since the growth rate and the migration speed of a planet areproportional to the disk surface density nearby, a model for global evolution of protoplanetary disk is also necessary. We adopt self-similar solutions of viscous accretion disks. In the model of the disk surface density, we also include the effect of gas depletion due to the planetary gas capture. Furthermore, we also take account of disk dissipation due to the photoevaporation. Then the rate of disk dissipation due to the photoevaporation is a parameter.
From this model, we obtained evolution curves on the plane of the planet mass and orbital radius (Figure 1). The evolution curves are also expressed in an analytical form. Since both the growth rate and migration speed of a planet are proportional to the disk surface density nearby, the curves do not depend on the detail of the disk model. In Figure 1, we also plotted data of exoplanets. Masses of gas giants are clustered around 2 Jupiter mass (or 0.2% of the central-star mass). Such exoplanets do not migrate much during their formation. Even for the largest exoplanet (of which mass is 2% of the star mass), its orbital radius is reduced moderately (to 1/10). Many gas giants are located at around 2AU from their stars. This can be explained as solid cores are easily formed near snow lines of disks at ~3AU.
The termination of growth of each gas giant planet is mainly determined by the initial disk mass and the disk dissipation rate due to photoevaporation. Thus for a given disk dissipation rate, we can obtain initial disk masses corresponding to each planetary masses. Figure 2 plots the distribution of the initial disk masses obtained from the masses of exoplanets with our theoretical model. We find that the peak of our initial disk mass distribution agrees with the most common disk mass in observations (~0.02 solar masses, Andrews et al. 2010) if the disk dissipation rate is set to be ~3×10^{-9} solar mass per year.

Keywords: Exoplanet, giant planet, protoplanetary disk

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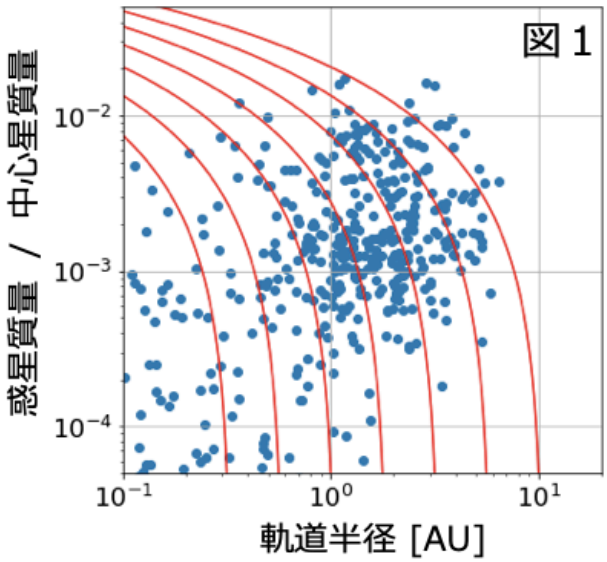

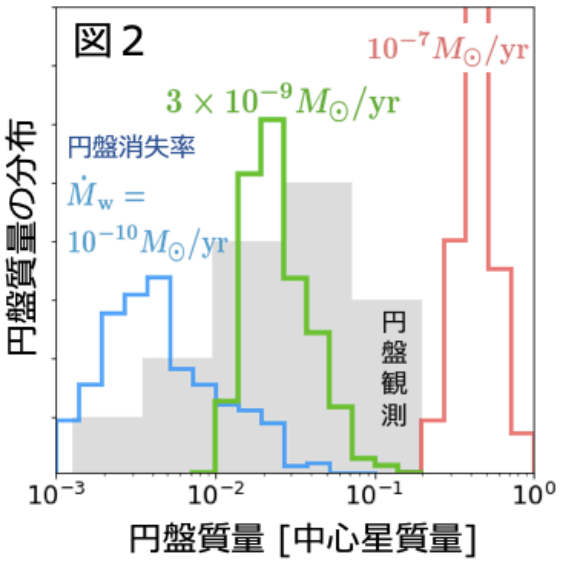

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Impact of resonance trapping of planetesimals during planetary migration on metallicities of close-in gas giants

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The physical properties of gas giant exoplanets have gradually become clear thanks to a rapid advance in exoplanet observations in recent years. According to some studies combining the internal structural modelling of gas giant planets with transit observations, the gas giant planets generally contain much more heavy elements (elements heavier than hydrogen and helium) than their central star. Such heavy element excess of gas giant planets is thought to have been brought about by the capture of planetesimals during the formation phases, but this hypothesis still has problems.

According to studies estimating the amount of planetesimals captured by a growing protoplanet, the amount of heavy elements captured in this process is at most ten Earth masses. The estimated amount is not large enough to explain the heavy element excess of the gas giant planets shown in the above studies. In order to solve this problem, this study investigates the capture of planetesimals during the planet migration process, which is different from the growth process investigated before. In particular, we focus on the capture of planetesimals by the mean motion resonances of a migrating gas giant planet (resonance trapping). Performing orbital calculations of planetesimals, we quantitatively discuss the effect of the resonance trapping on the capture of planetesimals by a migrating gas giant planet.

Keywords: Planet Formation, Heavy Elements, Planet Migration, Resonance Trapping

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Theoretical modeling of hydrogen line emission from accreting gas giants: comparison with observations of LkCa15b and PDS70b

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Recent direct imaging observation has detected some forming protoplanets. Although most of such observations used infra-red bands, also visible band observation, which covers H-alpha line, detected two protoplanetary candidates, LkCa15b and PDS70b. The observed luminosities of IR photon from the protoplanets correspond to the emission from the gas of thousands K. This is a reasonable temperature for photosphere of accreting protoplanets. On the other hand, the detected H-alpha luminosities exceed the emission of thousands K and correspond to tens of thousands of K. Such a hot gas originates in shock-heated gas. According to numerical simulations of hydrodynamics around forming planets, gas accreting towards protoplanets goes through several shocks. At some of the shocks, its flow velocity exceeds gas sound speed by several orders of magnitude. Thus, the shock heats the gas to tens of thousands of K, and the shock-heated gas can emit H-alpha of observable intensity. However, such a hot gas rapidly cools by hydrogen line radiation. Since the temperature changes with electron transitions proceeding, the hydrogen electron level distribution, which determines hydrogen line emission and extinction, never reaches its equilibrium state. Therefore, in this study, we modeled hydrodynamics of cooling flow after the shock, radiative transfer of hydrogen lines, and electron level transitions at the same time. Using this model, we estimated hydrogen line intensity as a function of gas velocity and mass flux at the shock. By comparing the results with the observational results, we will discuss the preferred picture of gas accretion towards protoplanets.

Keywords: LkCa15b, PDS70b, Shock heating, Hydrogen line, Hα

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Design of a Lyman alpha telescope LAICA2 for exoplanetary exploration

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Recently, small planets, which orbit around small cool stars have gained considerable attentions as objects of Earth-like exoplanetary exploration. These small planets can be detected by the transit observation. Moreover, if their atmospheres are rich in oxygen and receive high extreme ultraviolet (EUV) radiation, their oxygen atmosphere might expand (Kulikov et al., 2007, Tian et al., 2008b). Hence, the transit observation of expanded-oxygen absorption is considered to be effective to detect the Earth-like exoplanets. However, most of the EUV radiation cannot be measured, because it gets absorbed by the interstellar neutral hydrogen. Therefore, in order to estimate the EUV spectrum of the star, we quoted the empirically derived relationships between the total hydrogen Lyman alpha intensity and the EUV spectrum presented in Linsky et al. (2014). The deep space microspacecraft PROCYON is equipped with the Lyman Alpha Imaging Camera (LAICA). Based on LAICA, we designed the telescope LAICA2, which can measure the Lyman alpha intensity from distant stars. The field of view (FoV) of LAICA is wide for observation of widely expanded geocorona but that of LAICA2 is to be narrower for observation of distant stars. Therefore, in LAICA2, the focal length was extended by 1.5 times while maintaining a spot size, by making the primary mirror elliptical; in LAICA, both the primary and secondary mirror have a spherical shape. In addition, the influence of stray light was reduced by designing a baffle that can block the correspondent light path. We evaluated the stray light originated by internal reflection and scattering in the optical system: our analysis indicated that the influence of stray light on LAICA2 observations can be ignored.

Keywords: exoplanet, optical design

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Numerical experiments on thermal convection of highly compressible fluids: Influences for mantle convection of super-Earths

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We conduct a series of numerical experiments of thermal convection of highly compressible fluids in a two-dimensional rectangular box heated both from within and below, in order to study the mantle convection on super-Earths. The thermal conductivity and viscosity are assumed to exponentially depend on depth and temperature, respectively, while the variations in thermodynamic properties (thermal expansivity and reference density) with depth are taken to be relevant for the super-Earths with 10 times the Earth's. From our experiments we identified a distinct regime of convecting flow patterns induced by the interplay between the adiabatic temperature change and the spatial variations in viscosity and thermal conductivity. That is, for the cases with strong temperature-dependent viscosity and depth-dependent thermal conductivity, a "deep stratosphere" of stable thermal stratification is formed at the base of the mantle, in addition to thick stagnant lids at their top surfaces. In the "deep stratosphere", the fluid motion is insignificant particularly in the vertical direction in spite of smallest viscosity owing to its strong dependence on temperature. Our finding may further imply that some of super-Earths which are lacking in mobile tectonic plates on their top surfaces may have "deep stratospheres" at the base of their mantles.

Keywords: Super-Earths, mantle convection, adiabatic (de)compression

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Impact of Stellar Superflares on Planetary Habitability

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Environmental factors of crucial importance for exoplanetary habitability include the presence of bodies of liquid surface water, a dense atmosphere, planetary global magnetic field, and internal planetary dynamics . In addition, high-energy radiation due to exoplanetary space weather introduced by magnetic activity of a planet-hosting star can also play a crucial role in the definition of habitability.

Here, we present the first quantitative impact evaluation system of stellar activity on the habitability factors with an emphasis on Stellar Proton Events for several documented exoplanets examining the impact of CO2, H2, N2+O2 –rich atmospheres by introducing starspots of their hoststars, estimated using their rotational periods and lightcurves.

Simulations suggest that the estimated ground level dose for each planet, assuming a terrestrial-level atmospheric thickness, does not exceed the critical dose for complex (multi- cellular) life to persist, even for the planetary surface of Proxima Centauri b, Ross-128b and TRAPPIST-1 e. However when we consider the possible maximum flare for those host stars, at the terrestrial lowest atmospheric depth, the estimated dose reaches fatal levels on TRAPPIST-1 e and Ross-128 b. Continuous XUV radiation higher than that experienced by the Earth induces rapid atmospheric escape for those planetary systems , meaning the atmospheric depth might be substantially less than the Earth. In a scenario where the modelled planetary systems have 1/10 the atmospheric thickness of Earth, the radiation dose at Proxima Centauri b and TRAPPIST-1 e reaches near fatal levels just from relatively minor annually occurring flares from their hoststars.

Keywords: Stellar flare

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Studies of atmospheric structure in new very-hot Jupiter with high-resolution transmission spectroscopy

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In the last decade, the understanding of exoplanetary atmospheres has advanced considerably through spectroscopic observations during planetary transit events, known as transmission spectroscopy.

Transmission spectroscopy done by Charbonneau et al. (2002) using Hubble Space Telescope first detected Na in the atmosphere of the hot Jupiter HD209458b. Currently, alkali metals have been detected in some hot Jupiter atmospheres. (e.g. Sing et al. 2012) Alkali metal lines are one of the most important key opacity sources because the Na I and K I resonance doublets are thought to be the cause of the generally low albedos, as the alkali metal's wide line wings absorb almost all of the incoming stellar irradiation.

Especially, high-resolution transmission spectroscopy of Na absorption lines can investigate temperature of a thermosphere where temperature is increased by stellar X-ray and EUV irradiation and the atmospheric escape is caused because the depth of Na absorption lines is deep and comparable to that of Hα absorption line which is formed in upper atmosphere (Huang et al. 2017).

We performed high-resolution transmission spectroscopy for WASP-76 with Subaru HDS. For WASP-76b, we detected strong Na D absorption lines and measured an average absorption depth of 0.427 ±0.018% for a 3.0 Åpassband. We derived the temperatures of the upper atmosphere as about 3700 K (Na D1) and 4000 K (Na D2) on the assumption of an atomic layer where an atomic hydrogen is dominated. As the equilibrium temperature is about 2160K, these results suggest the existence of a thermosphere.

Keywords: Exoplanet atmosphere

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Doppler Tomographic Analysis for the Planetary Orbital Precession of WASP-33b

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The apparent angle between the stellar spin axis and the planetary orbital axis, which is called orbital obliquity (λ), is one of the important parameters for understanding the orbital evolution. If a planet has followed an orbital evolution like those in our solar planets evolve, its orbit will be aligned with the stellar spin. This orbit is called a prograde orbit ($|\lambda| < 90$ deg) and many exoplanets orbit with the direction. However, it is clear that there are few exoplanets with retrograde orbits ($|\lambda| > 90$ deg), which is the opposite case of our solar system. Doppler tomography (DT) is one of the methods to measure λ. In this method, when a planet covers part of the stellar surface during a planetary transit, a planetary shadow appears in the stellar line profile which is broadened by its rapid stellar spin. Then, λ can be derived by the track of the shadow. The distance between the center of the stellar surface, which is called the impact parameter (b), can be measured by DT. Moreover, The planetary shadow appears more easily when the central star spins faster, which makes the measurement of these parameters more easily.

The previous study [1] found that the values of λ and b of the hot Jupiter WASP-33b, which has a 1.2-day period retrograde circular orbit around a rapidly rotating and pulsating A-type star, changed slightly from 2008 and 2014. They detected its orbital precession due to its slightly flattened central star. However, only two observational epochs, from 2008 and 2014, were used in the previous study [1]. We aim to confirm and more precisely measure the precession using not only the dataset of 2008 and 2014 but also a previously unpublished dataset from 2011.

In our research, we used observational data of WASP-33 which was obtained using the High Dispersion Spectrograph (HDS) on the 8.2m Subaru telescope on 19th October 2011 (UT), as well as data sets of the previous study [1] which has already been analyzed up to their line profiles. First, we obtained the average line profile of each exposure from a large number of absorption lines by Least-Squares-Deconvolution (LSD). Subtracting the average stellar line profile of all exposures from the one from each exposure, we got the planetary shadow showing a retrograde orbit and a component from stellar pulsations. In order to make the measurement of the planetary parameters more easily, we extracted only the planetary shadow by Fourier filtering used in the previous study [1].

In order to make the measurement of the planetary parameters, we adopted an MCMC analysis for the three filtered data with our planetary shadow model with Fourier filtering. Considering b and λ of WASP-33b is changeable, our results show that b changed linearly, but the change of λ was not so that λ in 2011 was not intermediate between ones in 2008 and 2014. In the case that λ is fixed but b is changeable, we found that the change of b was comparable to one of the former case. In either case, our results indicated that the orbital precession seems to be different than one from the previous study [1].

[1] Johnson et al. 2015

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TESS Follow-up Observation with IRSF/SIRIUS

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1. The University of Tokyo, 2. Astrobiology Center, NINS, 3. Kyoto Sangyo University, 4. Nagoya University

We observed planetary candidates from Transiting Exoplanet Survey Satellite (**TESS**) with **1.4m telescope IRSF** in South Africa, as part of TESS Follow-Up Observing Program (**TFOP**).
Though it is predicted that TESS will find several thousands of exoplanet candidates, a large part of them will be **false positives produced by eclipsing binaries**[1]. In order to distinguish them, follow-up observations from ground-based telescopes are important. IRSF and its simultaneous-3 color infrared imager SIRIUS is suitable for follow-up observation.
Compared to TESS, IRSF/SIRIUS has **higher angular resolution**(0.453arcsec/pix), and it enables us to derive each stars' light curve inside TESS aperture and identify the culprit of brightness variability. Also its **simultaneous photometry in J, H, Ks band** is useful to clarify wavelength dependence of transit depth and then distinguish blended binaries from transiting planets. However, because IRSF/SIRIUS is not originally designed for transit observations, it required a new pipeline to convert raw images into the data and figures for transit analysis.
Our new pipeline can take photometry of all detectable stars inside the field of view, and create each light curve in simple process. It also calculates the separation and the magnitude difference between each stars, and they are useful to eliminate diluted eclipsing binaries. Besides, it can calculate the correlation between brightness variability and the effects from instrument, and fit light curves with a simple linear model of such systematics. The pipeline made us able to submit the observational results to TFOP team within a few days.
The observations were conducted from October to November in 2018. 45 transits of 35 candidates were observed. We reported our results to TFOP team on 8 exoplanets, TOI 125, TOI 142, TOI 157, TOI 174, TOI 178, TOI 179, TOI 193 and TOI212. Our contribution was useful to detect exoplanets and to eliminate eclipsing binaries.
Above all, for **TOI 125**, our observation contributed a lot to eliminate diluted eclipsing binaries. TFOP team detected that TOI 125 is a K dwarf with 2 confirmed sub-Neptune sized planets(2.76R_E, 2.79R_E) and 3 planetary candidates. The ratio of orbital periods between planet c and b is slightly smaller than an 2:1 commensurability, and it makes this system dynamically interesting.
In our poster, we will introduce the details of our pipeline and several observational results.
[1] Sullivan et al.(2015), ApJ, 809, 77

Keywords: TESS, Transit, Photometry, Infrared, Observation

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Status of the Multi-band Cameras for Transiting Exoplanets MuSCAT1,2 and New Results in 2018

*Akihiko Fukui[1], Norio Narita[2], Nobuhiko Kusakabe[2], Motohide Tamura[2,1], Kiyoe Kawauchi[1], John Livingston[1], Jerome de Leon[1], Noriharu Watanabe[3], Yuka Terada[1], Mayuko Mori[1], Taku Nishiumi[4]

1. The University of Tokyo, 2. Astrobiology Center, 3. SOKENDAI, 4. Kyoto Sangyo University

MuSCAT and MuSCAT2 are optical multi-band cameras develped for observing transiting exoplanets. MuSCAT was developed for the Okayama 188cm telescope of NAOJ in 2014, and MuSCAT2 was developed for the TCS 1.52m telescope in Teide observatory, the Canary Islands, Spain, in 2017. MuSCAT and MuSCAT2 have the capabilities of simultaneously obtaining 3- (g-, r-, and z_s-) and 4- (g-, r-, i-, and z_s-) band images, respectively. One of the main purposes of these instruments is to validate and caracterize the planetary candidates discovered by the all-sky transiting planet survey satellite TESS, which was launched in April 2018.

In 2018, there was no much observation with MuSCAT because that it was the transition period of the telescope operation from NAOJ to the user community, and that there were several troubles in the instrument. However, from January 2019 we have observed with MuSCAT for about 1 week per month in average.

As for MuSCAT2, we have observed more than 250 nights in corraboration with the co-researchers in Instituto de Astrofisica de Canarias (IAC) in 2018. We have improved the operation system and remote-observing system to reduce the load of the observers and to make it possible to observe from Japan smoothly.

TESS has observed only the Southern sky in the first year, and there were few TESS planetary candidates that can be observed with MuSCAT and MuSCAT2 in 2018. Instead, in this year we have observed planetary candidates discovered by the Kepler's ecliptic survey or ground-based transit surveys, as well as low-density transiting planets to observe their atmospheres.

In this contribution, we will report the status of the operations of MuSCAT and MuSCAT2 in 2018, and show new results obtained from these instruments.

Keywords: transiting exoplanets, TESS, atmosphere of exoplanets

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[J] Poster | P (Space and Planetary Sciences)：P-AE Astronomy & Extrasolar Bodies

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_7

[P-AE20] Exoplanet

convener:Masahiro Ikoma(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Norio Narita(University of Tokyo)

Exoplanetary science, which began with the discovery of a hot Jupiter in 1995, has reached a major turning point by the discovery of countless super-Earths by the Kepler mission. More recently, planets that are similar in size to the Earth and also receive similar amounts of stellar radiation (namely, located in the so-called habitable zone) have been discovered around nearby stars such as Proxima Centauri and TRAPPIST-1. As a result, not only theoretical, but also observational studies on the atmospheres and surface environments of Earth-like exoplanets have been started. Moreover, the number of planets discovered around early-type and late-type stars has become large enough that the occurrence rate and orbital distribution of planets around a wide variety of host stars have become clear. Thus, new observational insights, which become the basis of pan-planet formation theory, are now gathering. While exoplanets have been mainly targeted for astronomy until recently, it can be said that earth planetary science is finally becoming a research field to make a central contribution. In this session, we aim to share cutting-edge research results in exoplanetary science which is in such a transition period.

[PAE20-P01] An interpretation of exoplanet masses and orbital radii with a theoretical model of gas giant formation

*Kiyoka Murase[1], Hidekazu Tanaka[1] (1.TOHOKU UNIVERSITY)

[PAE20-P02] Impact of resonance trapping of planetesimals during planetary migration on metallicities of close-in gas giants

*Sho Shibata[1], Masahiro Ikoma[1] (1.Graduate School of Science, The University of Tokyo)

[PAE20-P03] Theoretical modeling of hydrogen line emission from accreting gas giants: comparison with observations of LkCa15b and PDS70b

*Yuhiko Aoyama[1], Masahiro Ikoma[1], Gabriel-Dominique Marleau[2], Christoph Mordasini[3] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Institute for Astronomy and Astrophysics, Eberhard Karls University of Tubingen, 3.Physics Institute, University of Bern)

[PAE20-P04] Design of a Lyman alpha telescope LAICA2 for exoplanetary exploration

*Toru Muraoka[1], Go Murakami[2], Shingo Kameda[1] (1.Rikkyo University, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

[PAE20-P05] Numerical experiments on thermal convection of highly compressible fluids: Influences for mantle convection of super-Earths

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[PAE20-P07] Studies of atmospheric structure in new very-hot Jupiter with high-resolution transmission spectroscopy

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[PAE20-P09] TESS Follow-up Observation with IRSF/SIRIUS

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1. TOHOKU UNIVERSITY

About 4000 exoplanets have been detected and their statistical properties such as mass and orbital distributions become clear. However, the origin of these distributions is still uncertain. In this study, applying a recent core accretion model to data ofexoplanets, we clarify whether it is possible to explain the observed distributions ofmasses and orbital radii, and in what protoplanetary disk they can be explain.
We adopt the following theoretical model of gas giant formation in this study. We use the model of Tanigawa & Tanaka (2016) for the mass growth rate (i.e., the gasaccretion rate onto a planet) and the latest model of Kanagawa et al.(2018) for the planetary migration speed. Those are reliable because of their consistency with severalresults of hydrodynamic simulations. For simplification, interactions among multiple planets are ignored. Since the growth rate and the migration speed of a planet areproportional to the disk surface density nearby, a model for global evolution of protoplanetary disk is also necessary. We adopt self-similar solutions of viscous accretion disks. In the model of the disk surface density, we also include the effect of gas depletion due to the planetary gas capture. Furthermore, we also take account of disk dissipation due to the photoevaporation. Then the rate of disk dissipation due to the photoevaporation is a parameter.
From this model, we obtained evolution curves on the plane of the planet mass and orbital radius (Figure 1). The evolution curves are also expressed in an analytical form. Since both the growth rate and migration speed of a planet are proportional to the disk surface density nearby, the curves do not depend on the detail of the disk model. In Figure 1, we also plotted data of exoplanets. Masses of gas giants are clustered around 2 Jupiter mass (or 0.2% of the central-star mass). Such exoplanets do not migrate much during their formation. Even for the largest exoplanet (of which mass is 2% of the star mass), its orbital radius is reduced moderately (to 1/10). Many gas giants are located at around 2AU from their stars. This can be explained as solid cores are easily formed near snow lines of disks at ~3AU.
The termination of growth of each gas giant planet is mainly determined by the initial disk mass and the disk dissipation rate due to photoevaporation. Thus for a given disk dissipation rate, we can obtain initial disk masses corresponding to each planetary masses. Figure 2 plots the distribution of the initial disk masses obtained from the masses of exoplanets with our theoretical model. We find that the peak of our initial disk mass distribution agrees with the most common disk mass in observations (~0.02 solar masses, Andrews et al. 2010) if the disk dissipation rate is set to be ~3×10^{-9} solar mass per year.

Keywords: Exoplanet, giant planet, protoplanetary disk

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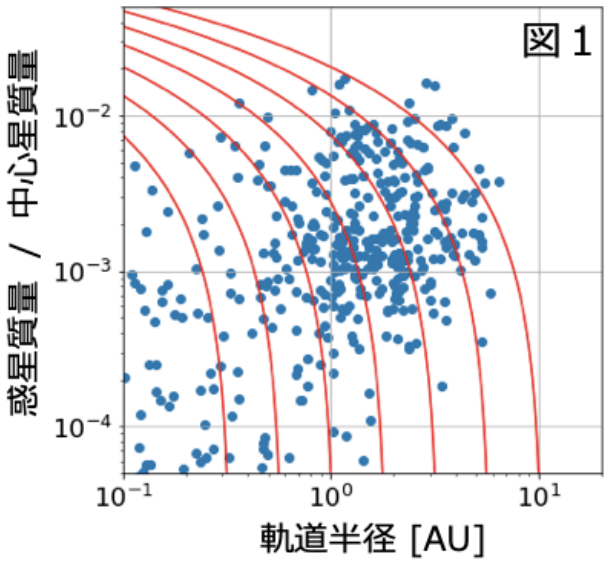

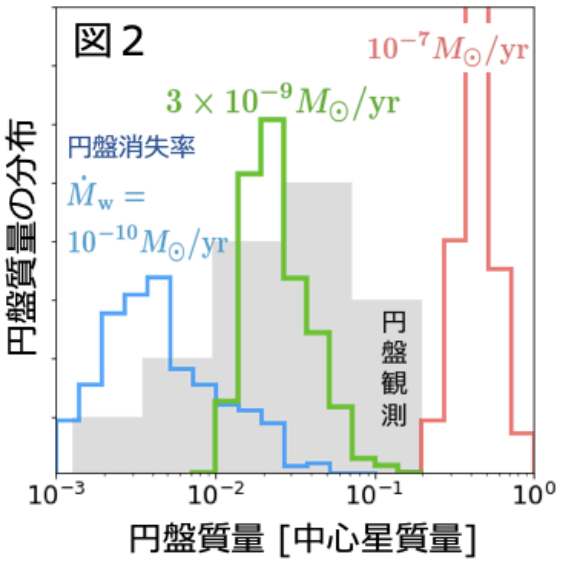

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Impact of resonance trapping of planetesimals during planetary migration on metallicities of close-in gas giants

*Sho Shibata[1], Masahiro Ikoma[1]

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The physical properties of gas giant exoplanets have gradually become clear thanks to a rapid advance in exoplanet observations in recent years. According to some studies combining the internal structural modelling of gas giant planets with transit observations, the gas giant planets generally contain much more heavy elements (elements heavier than hydrogen and helium) than their central star. Such heavy element excess of gas giant planets is thought to have been brought about by the capture of planetesimals during the formation phases, but this hypothesis still has problems.

According to studies estimating the amount of planetesimals captured by a growing protoplanet, the amount of heavy elements captured in this process is at most ten Earth masses. The estimated amount is not large enough to explain the heavy element excess of the gas giant planets shown in the above studies. In order to solve this problem, this study investigates the capture of planetesimals during the planet migration process, which is different from the growth process investigated before. In particular, we focus on the capture of planetesimals by the mean motion resonances of a migrating gas giant planet (resonance trapping). Performing orbital calculations of planetesimals, we quantitatively discuss the effect of the resonance trapping on the capture of planetesimals by a migrating gas giant planet.

Keywords: Planet Formation, Heavy Elements, Planet Migration, Resonance Trapping

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Theoretical modeling of hydrogen line emission from accreting gas giants: comparison with observations of LkCa15b and PDS70b

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Recent direct imaging observation has detected some forming protoplanets. Although most of such observations used infra-red bands, also visible band observation, which covers H-alpha line, detected two protoplanetary candidates, LkCa15b and PDS70b. The observed luminosities of IR photon from the protoplanets correspond to the emission from the gas of thousands K. This is a reasonable temperature for photosphere of accreting protoplanets. On the other hand, the detected H-alpha luminosities exceed the emission of thousands K and correspond to tens of thousands of K. Such a hot gas originates in shock-heated gas. According to numerical simulations of hydrodynamics around forming planets, gas accreting towards protoplanets goes through several shocks. At some of the shocks, its flow velocity exceeds gas sound speed by several orders of magnitude. Thus, the shock heats the gas to tens of thousands of K, and the shock-heated gas can emit H-alpha of observable intensity. However, such a hot gas rapidly cools by hydrogen line radiation. Since the temperature changes with electron transitions proceeding, the hydrogen electron level distribution, which determines hydrogen line emission and extinction, never reaches its equilibrium state. Therefore, in this study, we modeled hydrodynamics of cooling flow after the shock, radiative transfer of hydrogen lines, and electron level transitions at the same time. Using this model, we estimated hydrogen line intensity as a function of gas velocity and mass flux at the shock. By comparing the results with the observational results, we will discuss the preferred picture of gas accretion towards protoplanets.

Keywords: LkCa15b, PDS70b, Shock heating, Hydrogen line, Hα

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Design of a Lyman alpha telescope LAICA2 for exoplanetary exploration

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Recently, small planets, which orbit around small cool stars have gained considerable attentions as objects of Earth-like exoplanetary exploration. These small planets can be detected by the transit observation. Moreover, if their atmospheres are rich in oxygen and receive high extreme ultraviolet (EUV) radiation, their oxygen atmosphere might expand (Kulikov et al., 2007, Tian et al., 2008b). Hence, the transit observation of expanded-oxygen absorption is considered to be effective to detect the Earth-like exoplanets. However, most of the EUV radiation cannot be measured, because it gets absorbed by the interstellar neutral hydrogen. Therefore, in order to estimate the EUV spectrum of the star, we quoted the empirically derived relationships between the total hydrogen Lyman alpha intensity and the EUV spectrum presented in Linsky et al. (2014). The deep space microspacecraft PROCYON is equipped with the Lyman Alpha Imaging Camera (LAICA). Based on LAICA, we designed the telescope LAICA2, which can measure the Lyman alpha intensity from distant stars. The field of view (FoV) of LAICA is wide for observation of widely expanded geocorona but that of LAICA2 is to be narrower for observation of distant stars. Therefore, in LAICA2, the focal length was extended by 1.5 times while maintaining a spot size, by making the primary mirror elliptical; in LAICA, both the primary and secondary mirror have a spherical shape. In addition, the influence of stray light was reduced by designing a baffle that can block the correspondent light path. We evaluated the stray light originated by internal reflection and scattering in the optical system: our analysis indicated that the influence of stray light on LAICA2 observations can be ignored.

Keywords: exoplanet, optical design

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Numerical experiments on thermal convection of highly compressible fluids: Influences for mantle convection of super-Earths

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We conduct a series of numerical experiments of thermal convection of highly compressible fluids in a two-dimensional rectangular box heated both from within and below, in order to study the mantle convection on super-Earths. The thermal conductivity and viscosity are assumed to exponentially depend on depth and temperature, respectively, while the variations in thermodynamic properties (thermal expansivity and reference density) with depth are taken to be relevant for the super-Earths with 10 times the Earth's. From our experiments we identified a distinct regime of convecting flow patterns induced by the interplay between the adiabatic temperature change and the spatial variations in viscosity and thermal conductivity. That is, for the cases with strong temperature-dependent viscosity and depth-dependent thermal conductivity, a "deep stratosphere" of stable thermal stratification is formed at the base of the mantle, in addition to thick stagnant lids at their top surfaces. In the "deep stratosphere", the fluid motion is insignificant particularly in the vertical direction in spite of smallest viscosity owing to its strong dependence on temperature. Our finding may further imply that some of super-Earths which are lacking in mobile tectonic plates on their top surfaces may have "deep stratospheres" at the base of their mantles.

Keywords: Super-Earths, mantle convection, adiabatic (de)compression

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Impact of Stellar Superflares on Planetary Habitability

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Environmental factors of crucial importance for exoplanetary habitability include the presence of bodies of liquid surface water, a dense atmosphere, planetary global magnetic field, and internal planetary dynamics . In addition, high-energy radiation due to exoplanetary space weather introduced by magnetic activity of a planet-hosting star can also play a crucial role in the definition of habitability.

Here, we present the first quantitative impact evaluation system of stellar activity on the habitability factors with an emphasis on Stellar Proton Events for several documented exoplanets examining the impact of CO2, H2, N2+O2 –rich atmospheres by introducing starspots of their hoststars, estimated using their rotational periods and lightcurves.

Simulations suggest that the estimated ground level dose for each planet, assuming a terrestrial-level atmospheric thickness, does not exceed the critical dose for complex (multi- cellular) life to persist, even for the planetary surface of Proxima Centauri b, Ross-128b and TRAPPIST-1 e. However when we consider the possible maximum flare for those host stars, at the terrestrial lowest atmospheric depth, the estimated dose reaches fatal levels on TRAPPIST-1 e and Ross-128 b. Continuous XUV radiation higher than that experienced by the Earth induces rapid atmospheric escape for those planetary systems , meaning the atmospheric depth might be substantially less than the Earth. In a scenario where the modelled planetary systems have 1/10 the atmospheric thickness of Earth, the radiation dose at Proxima Centauri b and TRAPPIST-1 e reaches near fatal levels just from relatively minor annually occurring flares from their hoststars.

Keywords: Stellar flare

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Studies of atmospheric structure in new very-hot Jupiter with high-resolution transmission spectroscopy

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In the last decade, the understanding of exoplanetary atmospheres has advanced considerably through spectroscopic observations during planetary transit events, known as transmission spectroscopy.

Transmission spectroscopy done by Charbonneau et al. (2002) using Hubble Space Telescope first detected Na in the atmosphere of the hot Jupiter HD209458b. Currently, alkali metals have been detected in some hot Jupiter atmospheres. (e.g. Sing et al. 2012) Alkali metal lines are one of the most important key opacity sources because the Na I and K I resonance doublets are thought to be the cause of the generally low albedos, as the alkali metal's wide line wings absorb almost all of the incoming stellar irradiation.

Especially, high-resolution transmission spectroscopy of Na absorption lines can investigate temperature of a thermosphere where temperature is increased by stellar X-ray and EUV irradiation and the atmospheric escape is caused because the depth of Na absorption lines is deep and comparable to that of Hα absorption line which is formed in upper atmosphere (Huang et al. 2017).

We performed high-resolution transmission spectroscopy for WASP-76 with Subaru HDS. For WASP-76b, we detected strong Na D absorption lines and measured an average absorption depth of 0.427 ±0.018% for a 3.0 Åpassband. We derived the temperatures of the upper atmosphere as about 3700 K (Na D1) and 4000 K (Na D2) on the assumption of an atomic layer where an atomic hydrogen is dominated. As the equilibrium temperature is about 2160K, these results suggest the existence of a thermosphere.

Keywords: Exoplanet atmosphere

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Doppler Tomographic Analysis for the Planetary Orbital Precession of WASP-33b

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The apparent angle between the stellar spin axis and the planetary orbital axis, which is called orbital obliquity (λ), is one of the important parameters for understanding the orbital evolution. If a planet has followed an orbital evolution like those in our solar planets evolve, its orbit will be aligned with the stellar spin. This orbit is called a prograde orbit ($|\lambda| < 90$ deg) and many exoplanets orbit with the direction. However, it is clear that there are few exoplanets with retrograde orbits ($|\lambda| > 90$ deg), which is the opposite case of our solar system. Doppler tomography (DT) is one of the methods to measure λ. In this method, when a planet covers part of the stellar surface during a planetary transit, a planetary shadow appears in the stellar line profile which is broadened by its rapid stellar spin. Then, λ can be derived by the track of the shadow. The distance between the center of the stellar surface, which is called the impact parameter (b), can be measured by DT. Moreover, The planetary shadow appears more easily when the central star spins faster, which makes the measurement of these parameters more easily.

The previous study [1] found that the values of λ and b of the hot Jupiter WASP-33b, which has a 1.2-day period retrograde circular orbit around a rapidly rotating and pulsating A-type star, changed slightly from 2008 and 2014. They detected its orbital precession due to its slightly flattened central star. However, only two observational epochs, from 2008 and 2014, were used in the previous study [1]. We aim to confirm and more precisely measure the precession using not only the dataset of 2008 and 2014 but also a previously unpublished dataset from 2011.

In our research, we used observational data of WASP-33 which was obtained using the High Dispersion Spectrograph (HDS) on the 8.2m Subaru telescope on 19th October 2011 (UT), as well as data sets of the previous study [1] which has already been analyzed up to their line profiles. First, we obtained the average line profile of each exposure from a large number of absorption lines by Least-Squares-Deconvolution (LSD). Subtracting the average stellar line profile of all exposures from the one from each exposure, we got the planetary shadow showing a retrograde orbit and a component from stellar pulsations. In order to make the measurement of the planetary parameters more easily, we extracted only the planetary shadow by Fourier filtering used in the previous study [1].

In order to make the measurement of the planetary parameters, we adopted an MCMC analysis for the three filtered data with our planetary shadow model with Fourier filtering. Considering b and λ of WASP-33b is changeable, our results show that b changed linearly, but the change of λ was not so that λ in 2011 was not intermediate between ones in 2008 and 2014. In the case that λ is fixed but b is changeable, we found that the change of b was comparable to one of the former case. In either case, our results indicated that the orbital precession seems to be different than one from the previous study [1].

[1] Johnson et al. 2015

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TESS Follow-up Observation with IRSF/SIRIUS

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We observed planetary candidates from Transiting Exoplanet Survey Satellite (**TESS**) with **1.4m telescope IRSF** in South Africa, as part of TESS Follow-Up Observing Program (**TFOP**).
Though it is predicted that TESS will find several thousands of exoplanet candidates, a large part of them will be **false positives produced by eclipsing binaries**[1]. In order to distinguish them, follow-up observations from ground-based telescopes are important. IRSF and its simultaneous-3 color infrared imager SIRIUS is suitable for follow-up observation.
Compared to TESS, IRSF/SIRIUS has **higher angular resolution**(0.453arcsec/pix), and it enables us to derive each stars' light curve inside TESS aperture and identify the culprit of brightness variability. Also its **simultaneous photometry in J, H, Ks band** is useful to clarify wavelength dependence of transit depth and then distinguish blended binaries from transiting planets. However, because IRSF/SIRIUS is not originally designed for transit observations, it required a new pipeline to convert raw images into the data and figures for transit analysis.
Our new pipeline can take photometry of all detectable stars inside the field of view, and create each light curve in simple process. It also calculates the separation and the magnitude difference between each stars, and they are useful to eliminate diluted eclipsing binaries. Besides, it can calculate the correlation between brightness variability and the effects from instrument, and fit light curves with a simple linear model of such systematics. The pipeline made us able to submit the observational results to TFOP team within a few days.
The observations were conducted from October to November in 2018. 45 transits of 35 candidates were observed. We reported our results to TFOP team on 8 exoplanets, TOI 125, TOI 142, TOI 157, TOI 174, TOI 178, TOI 179, TOI 193 and TOI212. Our contribution was useful to detect exoplanets and to eliminate eclipsing binaries.
Above all, for **TOI 125**, our observation contributed a lot to eliminate diluted eclipsing binaries. TFOP team detected that TOI 125 is a K dwarf with 2 confirmed sub-Neptune sized planets(2.76R_E, 2.79R_E) and 3 planetary candidates. The ratio of orbital periods between planet c and b is slightly smaller than an 2:1 commensurability, and it makes this system dynamically interesting.
In our poster, we will introduce the details of our pipeline and several observational results.
[1] Sullivan et al.(2015), ApJ, 809, 77

Keywords: TESS, Transit, Photometry, Infrared, Observation

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Status of the Multi-band Cameras for Transiting Exoplanets MuSCAT1,2 and New Results in 2018

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1. The University of Tokyo, 2. Astrobiology Center, 3. SOKENDAI, 4. Kyoto Sangyo University

MuSCAT and MuSCAT2 are optical multi-band cameras develped for observing transiting exoplanets. MuSCAT was developed for the Okayama 188cm telescope of NAOJ in 2014, and MuSCAT2 was developed for the TCS 1.52m telescope in Teide observatory, the Canary Islands, Spain, in 2017. MuSCAT and MuSCAT2 have the capabilities of simultaneously obtaining 3- (g-, r-, and z_s-) and 4- (g-, r-, i-, and z_s-) band images, respectively. One of the main purposes of these instruments is to validate and caracterize the planetary candidates discovered by the all-sky transiting planet survey satellite TESS, which was launched in April 2018.

In 2018, there was no much observation with MuSCAT because that it was the transition period of the telescope operation from NAOJ to the user community, and that there were several troubles in the instrument. However, from January 2019 we have observed with MuSCAT for about 1 week per month in average.

As for MuSCAT2, we have observed more than 250 nights in corraboration with the co-researchers in Instituto de Astrofisica de Canarias (IAC) in 2018. We have improved the operation system and remote-observing system to reduce the load of the observers and to make it possible to observe from Japan smoothly.

TESS has observed only the Southern sky in the first year, and there were few TESS planetary candidates that can be observed with MuSCAT and MuSCAT2 in 2018. Instead, in this year we have observed planetary candidates discovered by the Kepler's ecliptic survey or ground-based transit surveys, as well as low-density transiting planets to observe their atmospheres.

In this contribution, we will report the status of the operations of MuSCAT and MuSCAT2 in 2018, and show new results obtained from these instruments.

Keywords: transiting exoplanets, TESS, atmosphere of exoplanets

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[E] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Kazuo Yoshioka(The University of Tokyo), Mitsunori Ozaki(Kanazawa University)

Not only national space agencies but some universities and even companies in the world are now leading a number of space science and exploration missions and also energetically initiating new research activities for satellite and rocket developments and international collaborations in these days because the Earth observations from the space and the space explorations could be achieved much easier than a few decades ago. The deployment to the space, which itself is not purely a scientific purpose but one of methods for better sciences, is vigorously motivating the technical innovation and the educational development. For successful space missions, it is also crucial to research and develop aim-oriented on-board instruments, and the fundamental research and development of observational instrumentation with future perspectives could totally lead space missions in some case. Detailed investigation and evaluation on various on-board instruments are needed during their proposals, selections, and fabrications in order to promote the missions, and inevitably we have to make multi-sided arrangements and evolution at every process and aspect of any type of space missions, independently of their mission sizes. In this session, we focus on these comprehensive research activities in the space and astronomical missions, including the mission integrations and the individual instrumental developments, and we also call many presentations showing the uniqueness and renovation regarding the mission strategy and methodology, and the status and latest results in the related state-of-the-art researches and developments, which would provide all of researchers and developers with invaluable opportunities for active discussion, information sharing, and collaboration toward the realization of more missions for more fruitful space sciences and explorations in nearer future.

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[PCG21-01] Current status and instrument development plan for future lunar exploration missions

★Invited Papers

*Makiko Ohtake[1] (1.Japan Aerospace Exploration Agency)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[PCG21-02] Development of a Neutral Particle TOF-MS for Future Solar System Explorations

*Daichi Fukuyama[1], Yoshifumi Saito[2], Kazushi Asamura[2], Shoichiro Yokota[3] (1.The university of Tokyo, 2.ISAS/JAXA, 3.Osaka University)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[PCG21-03] Development of Orbitrap Mass Spectrometer for in-situ measurements in solar system explorations

*Oya Kawashima[1], Satoshi Kasahara[1], Yoshifumi Saito[4], Shoichiro Yokota[2], Masafumi Hirahara[3], Seiji Sugita[1] (1.The university of tokyo, 2.Osaka University, 3.Nagoya University, 4.ISAS / JAXA)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[PCG21-04] A high-voltage pulsed power supply for on-site mass spectrometry in future solar system explorations

*Shoichiro Yokota[1], Yosuke Kawai[1], Jun Aoki[1], Yoshifumi Saito[2], Makiko Ohtake[2], Tatsuaki Okada[2] (1.Graduate School of Science, Osaka University, 2.ISAS/JAXA)

10:05 AM - 10:20 AM JST | 1:05 AM - 1:20 AM UTC

[PCG21-05] Development of DESTINY$^+$ Dust Analyzer and its expected science return

*Takayuki Hirai[1], Masanori Kobayashi[1], Tomoko Arai[1], Hiroshi Kimura[1], Ralf Srama[2], Harald Krueger[3]
(1.Chiba Institute of Technology, Planetary Exploration Research Center, 2.University of Stuttgart, 3.Max Planck Institute for Solar System Research)

10:20 AM - 10:30 AM JST | 1:20 AM - 1:30 AM UTC

Discussion

Current status and instrument development plan for future lunar exploration missions

*Makiko Ohtake[1]

1. Japan Aerospace Exploration Agency

Currently JAXA is planning a series of lunar exploration missions as a part of the international space exploration program. The goal of this program is to accomplish a Mars human exploration mission(s) after developing the required technology by doing. lunar exploration missions. In the initial stage of the program, JAXA is studying the following two lunar exploration missions.

1) Lunar polar exploration to evaluate the possibility of utilizing lunar polar water ice as a fuel resource for future lunar exploration. This mission will use pinpoint landing technology, which will be developed and demonstrated by the Smart Lander for Investigating the Moon (SLIM), for landing in a very limited and difficult area suitable for polar-ice investigation.

2) A lunar sample return mission (Human Enhanced Robotic Architecture for Lunar Exploration and Science; HERACLES), which will employ a lunar Gateway (Lunar Orbital Platform-Gateway) and will demonstrate the capability to return from the lunar surface that is required for a human landing mission on the Moon. This mission will bring back 15 kg of lunar samples and is capable of exploring tens of kilometers of the lunar surface by rover.

These missions are still before the pre-project phase, and the instruments that will be carried on these missions haven’t been selected. Recently, teams for conducting preliminary study of candidate instruments for the lunar polar exploration mission were selected based on proposals. And JAXA is planning to announce a request for information for the HERACLES instruments. Also, study teams for these missions in JAXA identified several key technologies to realize the missions and started to develop them (e.g., a rover system, a surface-drilling system, and night-survival technology). For efficient and optimal development of these technologies, the requirements and engineering limitations are being discussed among scientists and engineers, and iterative development is fundamental. This presentation will discuss the current status of the lunar polar exploration mission and the HERACLES mission including identified key technologies. A development plan for these technologies will also be discussed to accelerate discussion and interaction among people from different fields.

Keywords: Moon, Lunar polar exploration, HERACLES, international space exploration program

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Development of a Neutral Particle TOF-MS for Future Solar System Explorations

*Daichi Fukuyama[1], Yoshifumi Saito[2], Kazushi Asamura[2], Shoichiro Yokota[3]

1. The university of Tokyo, 2. ISAS/JAXA, 3. Osaka University

In-situ observation is important in solar system exploration because of the difficulty in returning samples from a gravitational celestial body. Especially, in-situ mass spectrometry of celestial surface material is indispensable to understand the evolution of the moon and planets since mass spectra bring us various information such as the isotope composition. For the purpose of in-situ material analysis, mass spectrometers are used for recent planetary explorations. In addition, observations by lunar explorer in recent years reports the result of remote sensing suggesting the existence of H_2O in the moon polar permanent shadow, but the existence is ambiguous since the observations have problems such as difficulty in discriminating between H_2O and OH. The need for a mass spectrometer to demonstrate the presence of water by in situ observation is increasing.

Mass spectrometers on planetary explorers must be compact and lightweight, but mass spectrometers that have both the compactness and high mass resolution have not been developed yet. Therefore, we are developing a compact and moderately high mass resolution TOF-MS (Time-Of-Flight Mass Spectrometer) for measuring neutral particles on the moon and planets.

TOF-MS accelerates ions with an electric field. The accelerated ions fly at a fixed distance and the mass information is obtained from their flight time. In general, the flight path of ions must be long for realizing high mass resolution. In order to increase flight distance without enlarging equipment, a reflectron type TOF- MS, which reflects ions by electric field is adopted. Since the ion trajectory is dispersed as the ion flight distance increases, the detection efficiency decreases when the number of reflection increases. Therefore, our new reflectron type TOF-MS is equipped with a triple reflection mode with high mass resolution and a single reflection mode with high sensitivity. These measurement modes can be switched electrically depending on the observation targets. Simulation results show that the mass resolution is 360 in the triple reflection mode and 180 in the single reflection mode. Currently, we are manufacturing a test model whose size and potential are optimized.
In this presentation we will report the design of our new reflectron type TOF-MS that is optimized by analytical calculation and numerical simulation.

Keywords: Solar System Exploration, Mass Spectromete

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Development of Orbitrap Mass Spectrometer for in-situ measurements in solar system explorations

*Oya Kawashima[1], Satoshi Kasahara[1], Yoshifumi Saito[4], Shoichiro Yokota[2], Masafumi Hirahara[3], Seiji Sugita[1]

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Previous mass spectrometry in solar system explorations has advanced our knowledge and understanding on the formation and evolution of planets, as well as the dynamics of space environment surrounding planets, moons, and other small bodies. Nonetheless, there are many important topics remaining to be addressed by higher-resolution mass spectrometry. Here we report our design of Orbitrap, which is a kind of Fourier-transform mass spectrometer, showing high mass resolution (m/dm ~ 10000) based on numerical simulations. We propose a simple and miniaturized ion storage unit in front of the multi-reflectron region, utilizing the potential drop by the electron beam for ionization. Such a high-resolution mass spectrometer will provide significant information on elemental and isotopic compositions in, on, and around planets and other solar system objects. For instance, discrimination between N_2(28.0062 u) and CO(27.9949 u) in the Martian atmosphere, which is essential for discussing atmospheric escape in the present and past, will be enabled.

Keywords: Mass Spectrometer, High Mass Resolution, Orbitrap

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A high-voltage pulsed power supply for on-site mass spectrometry in future solar system explorations

*Shoichiro Yokota[1], Yosuke Kawai[1], Jun Aoki[1], Yoshifumi Saito[2], Makiko Ohtake[2], Tatsuaki Okada[2]

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Isotope-ratio mass spectrometric analyses have been frequently utilized in laboratories for not only the earth planetary science but also other scientific and industrial fields. In the planetary science, such mass analyses of meteorites and returned samples provide detailed information regarding the origin and evolution. Recently on-site measurements by lander and rover missions including high-resolution mass spectrometry have opened the door to a new era of the planetary science. We argue that the on-site mass analysis is capable of directly determining the age of bodies and asteroids and the presence of water. For Japanese future lander and rover missions, we are now developing high-resolution mass spectrometers. Although high-performance mass spectrometers occupy the much room of laboratories, it is possible to develop the mass spectrometers for space applications because the key components including ion optics and electronics are in principle fabricated within the acceptable ranges in terms of the size, weight, and power consumption. In addition, we have already developed several spaceborne mass analyzers for the space plasma observation and have succeeded in mass analyses in space. After conducting the concept design of the mass spectrometers for landers and rovers, we conclude that the feasibilities are enough for the ion optics and almost all the components of the electronics. However, we have estimated relatively low feasibility for the high-voltage pulsed power supply which mostly determine the performance of the time-of-flight mass spectrometers. The laboratory high-voltage pulsed power supplies contain a 'black box' module as the key component that consumes much power. Therefore, we have started reconstructing a high-voltage pulsed power supply for spaceborne time-of-flight mass spectrometers. We have developed evaluation boards of the high-voltage pulsed power supply for reflectron-type multi-turn-type mass spectrometers, which is planned to be utilized in future Japanese landing missions. In this presentation, we will report the instrumentation and test results.

Keywords: High-voltage pulsed power supply, Mass spectrometry, Isotope

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Development of DESTINY$^+$ Dust Analyzer and its expected science return

*Takayuki Hirai[1], Masanori Kobayashi[1], Tomoko Arai[1], Hiroshi Kimura[1], Ralf Srama[2], Harald Krueger[3]

1. Chiba Institute of Technology, Planetary Exploration Research Center, 2. University of Stuttgart, 3. Max Planck Institute for Solar System Research

Demonstration and Experiment of Space Technology for INterplanetary voYage, Phaethon fLyby and dUst Science (DESTINY$^+$) led by Japan Aerospace Exploration Agency, Institute of Space and Astronautical Science (JAXA/ISAS) will be launched in 2023. In addition to its two main engineering missions such as advancement of the electrical propulsion in space and acquisition of the fast flyby technique to the solar system small body, DESTINY$^+$ set two scientific missions to perform fast flyby observation of an active asteroid, 3200 Phaethon, and dust observation during interplanetary cruising and Phaethon flyby phases. In this presentation, we will introduce the dust analyzer for DESTINY$^+$ (DDA) and its expected science return.

DDA is an dust impact detector equipped with time-of-flight mass spectrometer (TOF-MS) which is the technologically advanced model of the dust analyzer (CDA) onboard the NASA's Saturn explorer, Cassini. DDA has been under development by a dust group at University of Stuttgart who developed CDA. Planetary Exploration Research Center at Chiba Institute of Technology (CIT/PERC) plays a role in interface adjustment between the spacecraft and DDA, operation planning, leading the DDA’s dust science, and so on.

Hypervelocity impact, >~1 km/s, of micrometeoroid on the target plate of the DDA sensor generates a plasma cloud composed of positive and negative ions and electrons. The applied electric field inside the sensor separates positive or negative particles from the other according to its polarity, and directs the separated ions into an ion collector. Then one can obtain TOF mass spectra and estimate the chemical composition of detected dust particles. The past dust analyzers had historically employed the positive ion detection mode in which the impact target is positively biased, however, DDA will have two sensor heads tuned for analyzing positive and negative ions respectively in order to reveal the chemical composition of dust particles with a wide variety of atomic and molecular species at the same observation condition. Another upgrade of DDA is a two-axes gimbal for aiming the sensor head towards the direction from which more incident of dust particles is expected.

During the interplanetary cruising phase between Earth and Venus orbit for about 2 years, DDA will observe the interplanetary dust originated from asteroids and comets and the interstellar dust incoming from outside the Solar System. At the Phaethon flyby, DDA will try to detect and analyze the ejected dust particles from Phaethon itself due to bombardment of the interplanetary dust.

Keywords: Interplanetary dust, Interstellar dust, 3200 Phaethon, Impact ionization, TOF-MS, Dust analyzer

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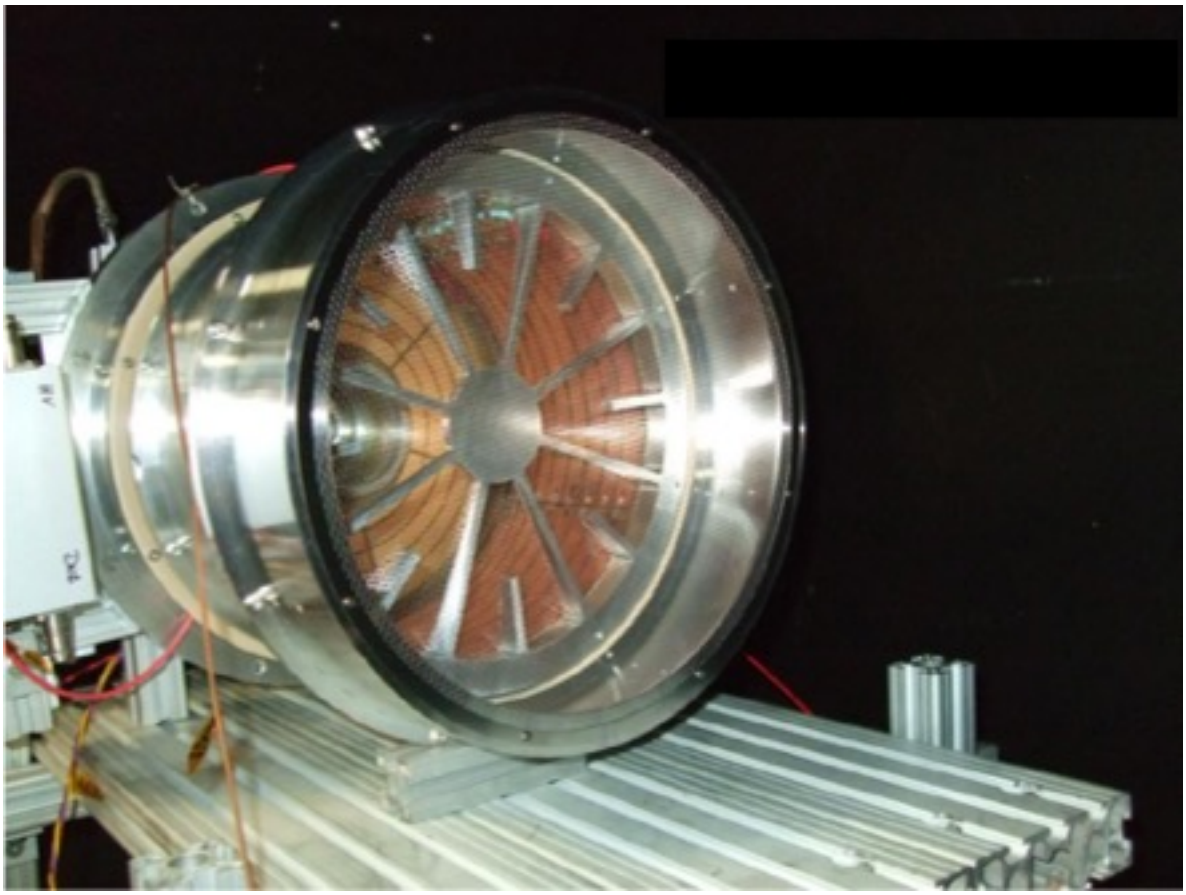

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[E] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Satoshi Kasahara , Mitsunori Ozaki(Kanazawa University)

Not only national space agencies but some universities and even companies in the world are now leading a number of space science and exploration missions and also energetically initiating new research activities for satellite and rocket developments and international collaborations in these days because the Earth observations from the space and the space explorations could be achieved much easier than a few decades ago. The deployment to the space, which itself is not purely a scientific purpose but one of methods for better sciences, is vigorously motivating the technical innovation and the educational development. For successful space missions, it is also crucial to research and develop aim-oriented on-board instruments, and the fundamental research and development of observational instrumentation with future perspectives could totally lead space missions in some case. Detailed investigation and evaluation on various on-board instruments are needed during their proposals, selections, and fabrications in order to promote the missions, and inevitably we have to make multi-sided arrangements and evolution at every process and aspect of any type of space missions, independently of their mission sizes. In this session, we focus on these comprehensive research activities in the space and astronomical missions, including the mission integrations and the individual instrumental developments, and we also call many presentations showing the uniqueness and renovation regarding the mission strategy and methodology, and the status and latest results in the related state-of-the-art researches and developments, which would provide all of researchers and developers with invaluable opportunities for active discussion, information sharing, and collaboration toward the realization of more missions for more fruitful space sciences and explorations in nearer future.

10:45 AM - 11:05 AM JST | 1:45 AM - 2:05 AM UTC

[PCG21-06] Satellite mission: PhoENiX (Physics of Energetic and Non-thermal plasmas in the X (= magnetic reconnection) region)

★Invited Papers

*Noriyuki Narukage[1], Mitsuo Oka[2], Yasushi Fukazawa[3], Keiichi Matsuzaki[4], Shin Watanabe[4], Taro Sakao[4], Sin-nosuke Ishikawa[5], Kouichi Hagino[6], Ikuyuki Mitsuishi[5], Tsunefumi Mizuno[3], Iku Shinohara[4], Masumi Shimojo[1], Shinsuke Takasao[5], Hiroshi Tanabe[7], Munetaka UENO[8], Tadayuki Takahashi[9], Takeshi Takashima[4], Masayuki Ohta[4] (1.National Astronomical Observatory of Japan, 2.Space Sciences Laboratory, The University of California, Berkeley, 3.Hiroshima University, 4.Japan Aerospace Exploration Agency, 5.Nagoya University, 6.Tokyo University of Science, 7.The University of Tokyo, 8.Kobe University, 9.Kavli Institute for the Physics and Mathematics of the Universe)

11:05 AM - 11:20 AM JST | 2:05 AM - 2:20 AM UTC

[PCG21-07] Development of ion drift velocity analyzer for sounding rocket and low-altitude satellite

*Takumi Abe[1], Shigeto Watanabe[2], Akinori Saito[3] (1.Department of Solar System Sciences, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Hokkaido Information University, 3.Graduate School of Science, Kyoto University)

11:20 AM - 11:35 AM JST | 2:20 AM - 2:35 AM UTC

[PCG21-08] SS-520-3 Sounding Rocket Experiment Targeting the Ion Outflow in the Polar Cusp / Aurora

*Yoshifumi Saito[1], Yasunobu Ogawa[2], Hirotsugu Kojima[3] (1.Department of Solar System Science, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.National Institute of Polar Research, 3.Research Institute for Sustainable Humanosphere, Kyoto University)

11:35 AM - 11:50 AM JST | 2:35 AM - 2:50 AM UTC

[PCG21-09] **Development of the chip implemented as high-speed current detection circuits for particle sensors**

*Motoyuki Kikukawa[2], Takahiro Zushi[2], Hirotsugu Kojima[2], Yoshifumi Saito[1] (1.JAXA, 2.Kyoto University)

11:50 AM - 12:10 PM JST | 2:50 AM - 3:10 AM UTC

[PCG21-10] GEO-X (GEOspace X-ray imager) : Imaging the dayside solar wind-terrestrial magnetosphere interaction

★Invited Papers

*Yuichiro Ezoe[1], Yoshizumi Miyoshi[2], Satoshi Kasahara[3], Ryu Funase[3], Harunori Nagata[4], Hiroshi Nakajima[5], Kumi Ishikawa[6], Atsushi Yamazaki[6], Hiroshi Hasegawa[6], Junko Hiraga[7], Masaki Fujimoto[6], Kazuhisa Mitsuda[6], Munetaka Ueno[8], Hiroyuki Koizumi[3], Yasuhiro Kawakatsu[6], Takahiro Iwata[6], Hironori Sahara[1] (1.Tokyo Metropolitan University, 2.Nagoya University, 3.University of Tokyo, 4.Hokkaido University, 5.Kanto Gakuin University, 6.ISAS/JAXA, 7.Kansei Gakuin University, 8.Kobe University)

12:10 PM - 12:15 PM JST | 3:10 AM - 3:15 AM UTC

Discussion

Satellite mission: PhoENiX (Physics of Energetic and Non-thermal plasmas in the X (= magnetic reconnection) region)

*Noriyuki Narukage[1], Mitsuo Oka[2], Yasushi Fukazawa[3], Keiichi Matsuzaki[4], Shin Watanabe[4], Taro Sakao[4], Sin-nosuke Ishikawa[5], Kouichi Hagino[6], Ikuyuki Mitsuishi[5], Tsunefumi Mizuno[3], Iku Shinohara[4], Masumi Shimojo[1], Shinsuke Takasao[5], Hiroshi Tanabe[7], Munetaka UENO[8], Tadayuki Takahashi[9], Takeshi Takashima[4], Masayuki Ohta[4]

1. National Astronomical Observatory of Japan, 2. Space Sciences Laboratory, The University of California, Berkeley, 3. Hiroshima University, 4. Japan Aerospace Exploration Agency, 5. Nagoya University, 6. Tokyo University of Science, 7. The University of Tokyo, 8. Kobe University, 9. Kavli Institute for the Physics and Mathematics of the Universe

We are planning a new solar satellite mission, "*PhoENiX*", for understanding of particle acceleration during magnetic reconnection, which are ubiquitous features exhibited by a wide range of plasmas in the universe. The main observation targets of this mission are solar flares, which are generated by magnetic reconnection and accelerate plasma particles. The sun is a unique target in the sense that it can be investigated in great detail with good spatial, temporal and energy resolutions.
The scientific objectives of this mission are (1) to identify particle acceleration sites, (2) to investigate temporal evolution of particle acceleration, and (3) to characterize properties of accelerated particles, during solar flares. In order to achieve these science objectives, the *PhoENiX* satellite is planned to be equipped with three instruments of (1) Photon-counting type focusing-imaging spectrometer in soft X-rays (up to ~10 keV) to observe the contexts of particle accelerations (e.g., shocks, plasmoids, flows, etc.), (2) Photon-counting type focusing-imaging spectrometer in hard X-rays (up to ~30 keV) to identify the accelerated particles, and (3) Spectropolarimeter in soft gamma-rays (spectroscopy is available in the energy range of from > 20 keV to < 600 keV; spectropolarimetry is available from > 60 keV to < 600 keV) to detect the anisotropy of accelerated particles. We plan to realize *PhoENiX* satellite mission around next solar maximum (around 2025).
The basic developments of key technologies for these instruments have been completed. The soft X-ray imaging spectroscopy is planned to be realized with the combination of high-precision glass-polished X-ray mirrors and high-speed CMOS cameras. The hard X-ray imaging spectroscopy consists of high-precision electroforming X-ray mirrors and CdTe cameras. The soft gamma-ray spectropolarimeter is a redesigned instrument of *Hitomi* / Soft Gamma-ray Detector (SGD) that has Compton cameras with active shields. Some of these technologies required for the X-ray imaging spectroscopy have been demonstrated by *FOXSI* sounding rocket series launched in 2012, 2014 and 2018. The *FOXSI* successfully obtained the focusing imaging spectroscopic data of the solar corona in X-rays (from ~0.5 keV to ~15 keV).
In this presentation, we explain the details of science goal and objectives, and instruments of *PhoENiX* mission.

Keywords: PhoENiX, Particle Acceleration, Magnetic Reconnection, Solar Flare, X-rays, Imaging Spectroscopy

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Development of ion drift velocity analyzer for sounding rocket and low-altitude satellite

*Takumi Abe[1], Shigeto Watanabe[2], Akinori Saito[3]

1. Department of Solar System Sciences, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. Hokkaido Information University, 3. Graduate School of Science, Kyoto University

The lower ionosphere is known as a unique region where charged particles and neutral particles co-exist. The charged particles tend to move in a direction different from neutral particles, because of a difference in those behaviors against the electromagnetic force. For example, the dynamo current and polarization electric field existing in this region are attributed to a difference in a collision frequency between ion and electron with neutral particles. Characteristic phenomena such as traveling ionospheric disturbance and equatorial spread F are generated due to the diversity of the particles in this region. The momentum transfer between the charged and neutral particles plays an important role in generating these phenomena. Sounding rocket is the most suitable platform which enables us to make in-situ measurement of the particles in this region because low-altitude satellite cannot be in orbit for a long time period because of the atmospheric drag. Thus, it is desirable to make a direct measurement of charged and neutral particles by using instrument on the sounding rocket to further understand such unresolved phenomena.

Chemical release experiment, such as Lithium Ejection System (LES) or Trimethyl Aluminum (TMA) instruments, have been adapted for sounding rocket experiment to get information on neutral wind in the lower ionosphere. In contrast, no instruments to measure a drift of the ionospheric ions is now available in Japan. Only a few studies on the neutral-ion coupling based on the simultaneous measurements on the rocket are available in the literature. Therefore, our understanding of interaction between charged and neutral particles in the weakly ionized plasma has not made much progress because of a lack of observational data. Unfortunately, it is very difficult to reproduce a coupling between charged and neutral particles on the ground, and direct measurements by sounding rocket or low altitude satellite is only the way to provide quantitative information.

Under such a background, we have started developing an ion drift velocity analyzer which enables us to estimate the ion drift velocity and density in the lower ionosphere. It is well known that Ion Drift Meter (IDM) or Retarding Potential Analyzer (RPA) had been installed on low-altitude satellite, such as Dynamic Explorer-2 and Atmospheric Explorer series. Our instrument will be required to have both of these functions. It will also be possible to make simultaneous measurement of the ion drift and neutral wind in the sounding rocket experiment if the present instrument is successfully developed and installed on the sounding rocket together with chemical release experiment. Then, we will be able to conduct quantitative discussion on the coupling between charged and neutral particles.

As the first step of the instrument development, a numerical simulation to design the internal structure was started. The instrument consists of RPA section in the front and multiple sector anodes in the end. Accuracy to estimate incident direction, speed, and temperature of thermal ions is evaluated from the simulation result. The prototype model is to be manufactured after we obtain a confident prospect that the instrument provides the ion density and velocity in a good accuracy. Then, we will put the prototype instrument in the vacuum chamber and evaluate its performance by generating ion drift. The latest status of our instrument development will be explained in the presentation.

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Keywords: ionosphere, ion drift, ion-neutral coupling, sounding rocket

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SS-520-3 Sounding Rocket Experiment Targeting the Ion Outflow in the Polar Cusp / Aurora

*Yoshifumi Saito[1], Yasunobu Ogawa[2], Hirotsugu Kojima[3]

1. Department of Solar System Science, Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. National Institute of Polar Research, 3. Research Institute for Sustainable Humanosphere, Kyoto University

In order to achieve collective understanding of the microphysics and its role (scale coupling) in the global scale to mesoscale phenomena in the polar ionosphere, Japan-Norway sounding rocket experiment program is now in progress. Although Japanese sounding rocket SS-520-3 was planned to be launched from Ny-Ålesund, Svalbard in Spitsbergenin December 2017, the launch was postponed due to mal-function of the timer equipment that was found during the final stage of the integration test. Since the timer equipment problem has already been completely fixed, SS-520-3 Payload Instrument team desires the earliest possible launch of the sounding rocket.

The main objective of this sounding rocket is to understand the particle acceleration processes that cause the ion outflow by making in-situ observation of the wave-particle interactionin the cusp region. SS-520-3 sounding rocket experiment aims to resolve the wave-particle interaction by making in-situ measurements in the polar cusp with newly developed instruments for the satellite mission. Since these wave-particle interactions are predicted to be effective above 800km altitude, a two-stage sounding rocket SS-520 whose apex can be higher than 750km is necessary. The rocket range where SS-520 can be launched targeting the cusp region is only Ny-Ålesund in Svalbard. Since simultaneous ground based optical observation of the cusp aurora is necessary to decide the launch timing, the best launch period is determined from the conditions of both the sunlight and the moonlight. From the sunlight condition, the best launch period is in the winter polar night that is around the winter solstice. On the other hand, two weeks before/after the new moon is the best launch period from the condition of the moonlight. Launch window for each day is 0700UT-1130UT (0800LT-1230LT: 1000MLT-1430MLT) when the cusp is possibly on the same magnetic field line as the trajectory of SS-520-3. SS-520-3 sounding rocket experiment is a part of the comprehensive observation campaign including ground-based radar and optical observations. SS-520-3 sounding rocket experiment is also one of the projects participating in “A Grand Challenge Initiative (GCI) Cusp program” that is a large-scale international collaboration for targeting advancement in the common understanding of cusp region space physics.

Although SS-520-3 Payload Instrument team desires the earliest possible launch of the sounding rocket, the severe budgetary situation at ISAS in 2018 prevented the launch of SS-520-3 in winter 2018-2019. Approaching the solar minimum in this solar cycle, that will be in 2020, the opportunities that satisfy the launch condition will decrease since the latitude of cusp tends to be higher comparing the apex latitude of SS-520-3. In order to overcome this situation, SS-520-3 Payload Instrument team is considering to add possible ion outflow over morning side polar cap aurora or nightside auroral arc as alternative targets of SS-520-3 sounding rocket experiment.

Keywords: Sounding Rocket, Ion Outflow, Cusp, Aurora

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Development of the chip implemented as high-speed current detection circuits for particle sensors

*Motoyuki Kikukawa[2], Takahiro Zushi[2], Hirotsugu Kojima[2], Yoshifumi Saito[1]

1. JAXA, 2. Kyoto University

Plasma filling the space is very rarefied. Ions and electrons in space plasma do not exchange their kinetic energies through their collisions but through plasma waves. This is so-called “wave-particle interaction,” and it is indispensable for understanding space electromagnetic environments. The WPIA (Wave-Particle Interaction Analyzer) is a new sophisticated method that allows us to understand wave-particle interactions quantitatively. The WPIA was initially installed in the Arase satellite. The WPIA processes instantaneous wave vectors observed by a plasma wave receiver and velocity vectors of each particle observed by a plasma instrument. The high relative time precision for detecting vectors of plasma waves and particles is essential in the WPIA. This requires a synchronous performance of plasma wave receivers and particle instruments. We introduce a system that feeds particle detection pulses of particle detectors into plasma wave receivers to achieve the synchronization. This system can use the sampling clocks for waveforms to keep the high relative time precision between instant values of plasma waves and particle detections. The present study focuses on the part of the circuits dedicated to particle detections and feeds of corresponding pulses into plasma wave receivers. We use the ASIC (Application Specific Integrated Circuit) for integrating the above circuits as one small chip. The chip we developed consists of two stages. The first stage is the current-voltage conversion circuit. Outputs of particle detectors are a series of weak electron current pulses with their pulse widths less than a few tens of nanoseconds. The first stage picks up each current pulse and converts into voltage signals with enough amplitudes to drive the second stage. We designed high-speed circuits dedicated to the first stage. The second stage contains comparator and peak-hold circuits. The comparator ensures picking up real signals by setting a threshold level and the peak-hold circuit has a role to keep the level to connect to the next stage. In this study, we set the count rate of 106/s as the target value and we designed the circuits so that it is within 1 μs from the arrival of a particle to the convergence of the detection signal. Conventional circuits are made of discrete electronic parts. That requires large resources in their sizes and weights. However, the chip we developed is small and light-weight. In this study, we integrate detection circuits using ASIC technology and we aim to accommodate at least 16 channels of circuits within 5 mm square chip.

In this presentation, we show the details of the chip designed for the particle detection circuits. We also examine the verification test results in the operation of those circuits. Furthermore, we describe the development plan for future WPIA system integration.

Keywords: ASIC, WPIA

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GEO-X (GEOspace X-ray imager) : Imaging the dayside solar wind-terrestrial magnetosphere interaction

*Yuichiro Ezoe[1], Yoshizumi Miyoshi[2], Satoshi Kasahara[3], Ryu Funase[3], Harunori Nagata[4], Hiroshi Nakajima[5], Kumi Ishikawa[6], Atsushi Yamazaki[6], Hiroshi Hasegawa[6], Junko Hiraga[7], Masaki Fujimoto[6], Kazuhisa Mitsuda[6], Munetaka Ueno[8], Hiroyuki Koizumi[3], Yasuhiro Kawakatsu[6], Takahiro Iwata[6], Hironori Sahara[1]

1. Tokyo Metropolitan University, 2. Nagoya University, 3. University of Tokyo, 4. Hokkaido University, 5. Kanto Gakuin University, 6. ISAS/JAXA, 7. Kansei Gakuin University, 8. Kobe University

Understanding complex nature of the solar wind interaction with solar system objects such as the Earth’ s magnetosphere, the Martian exosphere, and the Jovian magnetosphere is crucial in planetary physics, heliophysics and astrophysics including exoplanet physics. Remote sensing imaging observations provide global variation of these environments as a function of solar winds as demonstrated about aurora ovals, the terrestrial plasmasphere, and the terrestrial ring current. Such observations are complimentary to in-situ electromagnetic and particle observations. Recently soft X-ray emission (0.1-2.0 keV) generated via charge exchange process of high charge state solar wind ions (O6+, N5+, …) with geocorona is discovered. Numerical simulations predict that this emission must allow us to image dayside solar wind-terrestrial magnetospheric interaction such as the magnetosheaths, the cusps and the shock. GEO-X is a Japanese small satellite mission carrying a novel wide-field of view X-ray telescope and a high speed X-ray detector to demonstrate the X-ray imaging of the Earth’ s magnetosphere. GEO-X aims observations of the dayside boundaries of the Earth’ s magnetosphere in the vicinity of the Moon around the next solar maximum.

Keywords: X-ray, Earth's magnetosphere

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[E] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo), Chairperson:Shingo Kameda, Mitsunori Ozaki(Kanazawa University)

Not only national space agencies but some universities and even companies in the world are now leading a number of space science and exploration missions and also energetically initiating new research activities for satellite and rocket developments and international collaborations in these days because the Earth observations from the space and the space explorations could be achieved much easier than a few decades ago. The deployment to the space, which itself is not purely a scientific purpose but one of methods for better sciences, is vigorously motivating the technical innovation and the educational development. For successful space missions, it is also crucial to research and develop aim-oriented on-board instruments, and the fundamental research and development of observational instrumentation with future perspectives could totally lead space missions in some case. Detailed investigation and evaluation on various on-board instruments are needed during their proposals, selections, and fabrications in order to promote the missions, and inevitably we have to make multi-sided arrangements and evolution at every process and aspect of any type of space missions, independently of their mission sizes. In this session, we focus on these comprehensive research activities in the space and astronomical missions, including the mission integrations and the individual instrumental developments, and we also call many presentations showing the uniqueness and renovation regarding the mission strategy and methodology, and the status and latest results in the related state-of-the-art researches and developments, which would provide all of researchers and developers with invaluable opportunities for active discussion, information sharing, and collaboration toward the realization of more missions for more fruitful space sciences and explorations in nearer future.

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[PCG21-11] Debye: a multi-spacecraft mission to solve the electron energization problem in the solar wind

★Invited Papers

*Fouad Sahraoui[2], Robert T Wicks[1], Daniel Verscharen[1], The Debye The Debye Team (1.Mullard Space Science Laboratory, Department of Space and Climate Physics, University College London, UK, 2.LPP CNRS Ecole Polytechnique)

2:05 PM - 2:25 PM JST | 5:05 AM - 5:25 AM UTC

[PCG21-12] Comet Interceptor mission to a dynamically new comet

★Invited Papers

*Shinnaka Yoshiharu[1], Shingo Kameda[2], Satoshi Kasahara[3], Hideyo Kawakita[1], Masanori Kobayashi[4], Ryu Funase[3], Ichiro Yoshikawa[3], Jones H Geraint[5], Colin Snodgrass[6] (1.Kyoto Sangyo University, 2.Rikkyo University, 3.The University of Tokyo, 4.Chiba Institute of Technology, 5.UCL, 6.The Open University)

2:25 PM - 2:45 PM JST | 5:25 AM - 5:45 AM UTC

[PCG21-13] The concept of AI3 and impactors

★Invited Papers

*Koji Wada[1], Jakob Deller[2], Jessica Agarwal[2], Hans Martin Braun[3], Kieran Carroll[4], Hannah Goldberg[5], Martin Jutzi[6], Özgür Karatekin[7], Tomáš Kohout[8], Sampsa Pursiainen[9], Birgit Ritter[7], Olaf Roders[2], Francisco da Silva Pais Cabral[10], Fredrik Sjoberg[11], Mika Takala[9], Esa Vilenius[2], Patrick Bambach[2], Ryo Ishimaru[1], Yutaka WADA[1], Masahiko Arakawa[12], Takanao Saiki[13] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Max Planck Institute, Göttingen, 3.RST Radar System Technik, 4.Gedex Systems Inc, 5.GOMSpace, 6.University of Bern, 7.Royal Observatory of Belgium, 8.University of Helsinki, 9.Tampere University of Technology, 10.GMV, 11.OHB, 12.Kobe University, 13.JAXA)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[PCG21-14] Observational Techniques for Energy Transport Verification in Space Plasmas and Waves Developed in the FACTORS Mission

*Masafumi Hirahara[1], Hirotsugu Kojima[2], Naritoshi Kitamura[3], Kazushi Asamura[4], Yoshifumi Saito[4] (1.Institute of Space-Earth Environmental Research, Nagoya University, 2.Research Institute of Sustainable Humanosphere, Kyoto University, 3.Graduate School of Science, The University of Tokyo, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[PCG21-15] Current status of Life Detection Microscope (LDM) for Mars surface exploration

*Yoshitaka Yoshimura[1], Akihiko Yamagishi[2], Takehiko Satoh[3], Atsuo Miyakawa[2], Eiichi Imai[4], Satoshi Sasaki[5], Kensei Kobayashi[6], Yoko Kebukawa[6], Tomoka Okada[6], Keigo Enya[3], Hikaru Yabuta[7], Takeshi Naganuma[7], Hajime Mita[8], Kazuhisa Fujita[3], Tomohiro Usui[3] (1.College of Agriculture, Tamagawa University, 2.Tokyo University of Pharmacy and Life Science, 3.Japan Aerospace Exploration Agency, 4.Nagaoka University of Technology, 5.Tokyo University of Technology, 6.Yokohama National University, 7.Hiroshima University, 8.Fukuoka Institute of Technology)

Debye: a multi-spacecraft mission to solve the electron energization problem in the solar wind

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Sub-ion (kinetic) scale turbulence has been the main focus of research in space plasmas in the last decade because of the crucial role that those scales play in energy dissipation and thus particle energization (heating or acceleration). These research topics are relevant to many (more distant) astrophysical plasmas that are not accessible to in-situ measurements (e.g., solar corona, ISM or accretion flows). In the solar wind, orbiting spacecraft such as Cluster, Themis and more recently MMS have allowed us to make a significant progress in understanding the problem of turbulence and energy dissipation at sub-ion and electron scales in space plasmas. Yet, key questions cannot be addressed by those missions or by the upcoming ones (e.g., Parker Solar Probe and Solar Orbiter) because of their instrumental limitations. We will discuss some of these scientific questions and instrumental limitations, then present a new multi-spacecraft mission concept, Debye, designed to solve the problem of turbulence and energy dissipation at electron scales in the solar wind. This mission is currently being considered for selection within the ESA/F1-class call released in 2018 with a strong participation from the Japanese space physics community.

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Comet Interceptor mission to a dynamically new comet

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'Comet Interceptor' is a proposed mission to the recent European Space Agency (ESA) call for F-class ('fast') missions. This is one of six mission concepts invited to submit detailed proposals. A decision is expected until late July 2019. The purpus of our misson is to characterise a dynamically-new comet or interstellar object like 'Oumuamua, which are visiting the inner Solar System for the first time, including its surface composition, shape, and structure, the composition of its gas coma for the first time. Our mission will launch to the Sun-Earth L2 point, where it will be stayed in a stable L2 halo orbit for a period of up to 2-3 years, until a suitable opportunity for a flyby mission to a dynamically new comet presents itself. Suitable targets will be comets that will have a perihelion distance closer than ~1.2 au and an ecliptic plane crossing time and location reachable with ~1.5 km/s delta-v from L2. Once a target is found, which expected to be within a few years based on predictions for comet discovery rates with the Large Synoptic Survey Telescope (LSST), the spacecraft will depart on an intercept trajectory. Before the flyby, the main spacecraft will resease at least two sub-spacecraft, parallel paths through the coma and past the nucleus to be sampled. This mission will give us a 3D snapshot of the cometary nucleus at the time of the flyby, testing spatial coma inhomogeneity, interaction with the solar wind on many scales, and monitoring of Lyα coma. This mission will be a unique measurement that was not possible with previous missions, in addition to the fact that we will target a dynamicall new comet, which will allow interesting comparisons to be made with the results from Rosetta target comet 67P/Churyumov-Gerasimenko. It is expected that the proposed mission includes contributions from Japan as well as ESA member countries.

Keywords: Comet Interceptor Mission, dynamically new comet

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The concept of AI3 and impactors

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"Asteroid In-situ Interior Investigation - 3way" (AI3) defines a mission to investigate the interior of a rubble pile asteroid with three different complementary measurements: radar tomography, determination of the gravity field, and seismic sounding. AI3 has been proposed to ESA F-Class call and passed the first selection.

A mothership serving as communication relay will carry 4 CubeSats in the orbit of asteroid Apophis, observing the PHA during its extremely close approach to earth in 2029, getting as close as 0.1 Lunar distances, which is within the geostationary orbit.

Depending on the elongated shape of Apophis the earth fly by will trigger dynamic events on the asteroid and allow for extremely high data rates during the observation.

Two identical DISCUS satellites will be deployed to leverage the multi-point approach enabled by CubeSat technology, taking radar measurements to reconstruct the interior using computed tomography as well as determining the gravity field and analyzing surface composition using a hyperspectral imager. After completing the characterization phase, one of the DISCUS satellites will descent to the surface and measure the local surface gravity at several points on the asteroid. In the final phase, two impacting CubeSats will generate seismic waves, to be detected by the DISCUS satellite on the surface. The impact will be observed in high spatial and temporal resolution to add important data for impact studies in a before unexplored energy regime.

The concept has recently been invited to submit a detailed proposal to the Phase-2 of the ESA F-Class call.

Keywords: Apophis, ESA F-Class, Rubble Pile Asteroids, CubeSats, PHAs, Impactor

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Observational Techniques for Energy Transport Verification in Space Plasmas and Waves Developed in the FACTORS Mission

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The Japanese space physics community is now conducting the FACTORS mission, which is the first space exploration mission using a formation flight configuration based on multiple satellites orbiting in the terrestrial polar magnetosphere-ionosphere-thermosphere coupling regions. It is well understood that the in-situ observations integrating the particle, field, wave measurements could bring us with unique opportunities for elucidating the dynamics of the space plasmas and the terrestrial/planetary upper atmospheres. Also in the FACTORS mission as the next community-leading mission after the ERG(Arase) satellite mission, we are planning to realize more advanced integrated measurement system than the ERG(Arase) as well as the unified research framework based on the satellite/ground-based observations and the data analysis/modeling/simulation approaches. One of the science objectives in FACTORS is the demonstrative and quantitative verification on the energy transport mechanisms emerging in the ionospheric ion accelerations in the perpendicular direction to local magnetic fields, which have been frequently observed as transversely accelerated ions(TAIs) by previous/ongoing satellites and sounding rockets at altitudes of several hundreds to a few tens of thousands of km in the terrestrial auroral regions. This type of ion accelerations is quite important not only in our understanding the elemental physical mechanisms in the space plasmas but also in the estimate of the amount of the outflowing/escaping terrestrial plasmas. Although it is definitely evident that the plasma waves excited/propagating in the ionosphere are the exclusive energy source for TAIs according to the statistical analyses of the observational results, it should be noted with a surprise that we have not reached any consensus which mode of plasma waves is dominantly or more effective in the ion accelerations. It should also be noticed that the plasma wave modes responsible for TAIs could change, dependent on the event regions, the ambient ionospheric conditions, and the energy ranges of the accelerated ions, which means the there are some observational difficulties especially in the case of single satellite mission because the observational information obtained by in-situ measurements with a single satellite are too much limited to separate time variations from spatial distributions. In the FACTORS mission, it is required to overcome these observational problems by applying the controllable flight formation and attitude configurations of multiple satellites with an adequate accuracy and additionally developing the innovative observational techniques in the ion and wave measurements. In order to identify the plasma wave modes responsible for TAIs, we utilize several types of advanced formation flight configurations of the multiple satellites for longer plasma waves. As the observational technique for shorter waves, an interferometry method using single electric field probes on each satellite would be applicable. In the ion measurements, it would be essential to develop and install two types of ion energy-mass spectrometers covering from the supra thermal to the low-energy ranges independently with wide and controllable field-of-views and adequate energy/angular resolutions to capture the core ion components by compensating the convective plasma drift motion in the auroral regions or trace the conical pitch-angle distributions of the accelerated and upwelling ions. It could also be a breakthrough to carry a gyrophase-resolving ion energy-mass spectrometer with the similar specification to the low-energy ion spectrometer. This presentation introduces the observational methodology and techniques with which we could demonstratively and

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quantitatively address the ionospheric ions accelerations from the viewpoint of wave-particle interaction mechanisms occurring universally in space.

Keywords: wave-particle interaction, upper atmospheric plasma, space plasma wave, integrated satellite observation, formation flight, advanced compact satellite

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Current status of Life Detection Microscope (LDM) for Mars surface exploration

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Today’s Mars is a cold and dry planet, but ancient Mars would have had a large amount of liquid water on the surface. Several billion years ago, Mars could have been similar to the early Earth from which life arose, and life may have also originated on Mars during this period. Although the Viking mission in 1976, which explored life on Mars, did not find evidence for life [1], many findings associated with the possibility of life have been discovered since the Viking mission: past and present aqueous environments, organic compounds, methane, reduced compounds for microorganism energy sources, and so on [2] [3]. These findings suggest that microorganisms might exist on Mars surface.

For searching extant microorganisms, a microscopic instrument would be a powerful tool, which directly images life forms and identify their shapes, sizes, and other morphological structures, but it has not been used in space missions yet. For *in situ* detection of microbial cells, we have proposed the Life Detection Microscope (LDM) which visualizes organic compounds by staining the samples with fluorescent pigments [4]. The LDM scans a volume of 1 mm^3 and detects organic compounds including cells and other biological materials in high sensitivity ($<10^4$ cells per gram clay). The fluorescent pigments have been selected to identify the fundamental features of cells by differentiating among organic compounds surrounded by membranes or enzyme activity. The LDM is also equipped with a high resolution imaging system (1 μm/pixel) which visualizes detailed life forms as well as regolith and dust particles [5]. Our investigation goals are the followings. 1) Identify cell-like structure in which organic compounds are enveloped by membrane, which may represent Martian life. 2) Search for organic compounds in Mars surface samples. The compounds include cells, other biological materials, and abiotic polycyclic aromatic hydrocarbon (PAH). 3) High-resolution characterization of regolith and dust particles. Here we will report the current status of the development of LDM.

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Keywords: Mars, fluorescent microscope

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[E] Poster | P (Space and Planetary Sciences)：P-CG Complex & General

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_5

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo)

Not only national space agencies but some universities and even companies in the world are now leading a number of space science and exploration missions and also energetically initiating new research activities for satellite and rocket developments and international collaborations in these days because the Earth observations from the space and the space explorations could be achieved much easier than a few decades ago. The deployment to the space, which itself is not purely a scientific purpose but one of methods for better sciences, is vigorously motivating the technical innovation and the educational development. For successful space missions, it is also crucial to research and develop aim-oriented on-board instruments, and the fundamental research and development of observational instrumentation with future perspectives could totally lead space missions in some case. Detailed investigation and evaluation on various on-board instruments are needed during their proposals, selections, and fabrications in order to promote the missions, and inevitably we have to make multi-sided arrangements and evolution at every process and aspect of any type of space missions, independently of their mission sizes. In this session, we focus on these comprehensive research activities in the space and astronomical missions, including the mission integrations and the individual instrumental developments, and we also call many presentations showing the uniqueness and renovation regarding the mission strategy and methodology, and the status and latest results in the related state-of-the-art researches and developments, which would provide all of researchers and developers with invaluable opportunities for active discussion, information sharing, and collaboration toward the realization of more missions for more fruitful space sciences and explorations in nearer future.

[PCG21-P01] Visible and ultraviolet imagers for auroral and airglow observations by FACTORS - a future satellite mission for understanding the coupling and transportation processes in the upper atmosphere

*Takeshi Sakanoi[1], Masafumi Hirahara[2], Takuo T. Tsuda[3], Kazushi Asamura[4], Yoshizumi Miyoshi[2], Tomo-Hiko Watanabe[5], Takanori Nishiyama[6], Shin-ichiro Oyama[2,7], Yoshifumi Saito[4], Keisuke Hosokawa[3], Hirotsugu Kojima[8], Naritoshi Kitamura[9], Yasunobu Ogawa[5], Masatoshi Yamauchi[10], Ayako Matsuoka[4], Naoshi Yagi[1], Fukizawa Fukizawa[1], Genki Ishizawa[11] (1.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2.ISEE, Nagoya University, 3.Graduate School of Informatics and Engineering, School of Informatics and Engineering, The University of Electro-Communications, 4.ISAS/JAXA, 5.Graduate School of Science, Nagoya University, 6.National Institute for Polar Research, 7.University of Oulu, Finland, 8.RISH, Kyoto University, 9.Graduate School of Science, the University of Tokyo, Tokyo, 10.IRF Kiruna, Sweden, 11.Graduate School of Science, Tohoku University)

[PCG21-P02] Spatio-temporal analysis of flash aurora using Convolutional Neural Network

*Toki Genda[1], Takumi Inoue[1], Mitsunori Ozaki[1], Satoshi Yagitani[1], Imamura Kousuke[1], Kazuo Shiokawa[2], Yoshizumi Miyoshi[2], Shin-ichiro Oyama[2], Ryuho Kataoka[3], Yusuke Ebihara[4], Keisuke Hosokawa[5] (1.Kanazawa Univ., 2.Nagoya Univ., 3.NIPR, 4.Kyoto Univ., 5.UEC)

[PCG21-P03] Study on the pulse noise removal technique for Pc1 geomagnetic pulsations on the ground by signal processing

*Fumiya Komase[1], Tomohiro Inoue[1], Mitsunori Ozaki[1], Satoshi Yagitani[1], Kazuo Shiokawa[2], Masahito Nose[2], Tsutomu Nagatsuma[3] (1.Kanazawa Univ., 2.Nagoya Univ., 3.NICT)

[PCG21-P04] Application of magneto-impedance sensor to geomagnetic field measurements

*Masahito Nose[1], Reiko Nomura[2], Kazushi Asamura[3], Hitoshi Aoyama[4], Takeshi Kawano[4], Ayako Matsuoka[3], Kentarou Kitamura[5], Yukinobu Koyama[6], Haruhisa Matsumoto[7], Masafumi Hirahara[1] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.National Astronomical Observatory of Japan, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 4.Aichi Steel Corporation, 5.National Institute of Technology, Tokuyama College, 6.National Institute of Technology, Oita College, 7.Research and Development Directorate, Japan Aerospace Exploration Agency)

[PCG21-P05] Observation of the Ionospheric Currents by the CubeSat at the Low and Middle Latitude

*Kentarou Kitamura[1], Kazumasa Imai[2], Taku Takada[2], Manabu Shinohara[3], Makoto Wakabayashi[4], KOSEN Space Collaboration Group (1.National Institute of Technology, Tokuyama Collge, 2.National Institute of Technology, Kochi Collge, 3.National Institute of Technology, Kagoshima Collge, 4.National Institute of Technology, Niihama Collge)

[PCG21-P06] Basic study on miniaturization of electric field instrument for plasma wave observations by ASIC technology

*Yuya Tokunaga[1], Mitsunori Ozaki[1], Keigo Ishisaka[2], Hirotsugu Kojima[3], Satoshi Yagitani[1], Takahiro Zushi[3] (1.Kanazawa University, 2.Toyama Prefectural University, 3.Kyoto University)

[PCG21-P07] Evaluation of radiation tolerance of electronics parts used for the ultra-small mission

*Riku Katsuse[1], Kazuo Yoshioka[1], Masaki Kuwabara[2], Reina Hikida[1], Shogo Arao[1], Ichiro Yoshikawa[1] (1.The university of Tokyo , 2.Institute of Space and Astronautical Science)

[PCG21-P08] A method to quantitatively evaluate Non-evaporable-getter pump for use in space science mission

*Seiya Nishimura[1], Ichiro Yoshikawa[1], Kazuo Yoshioka[1], Shogo Arao[1], Zhang Tianxu[1] (1.The university of tokyo)

[PCG21-P09] Interpretation on slight asymmetry of analyzer characteristics of MIA onboard the Mio by means of a model calculation of 3-D potential distribution

*Wataru Miyake[1], Yoshifumi Saito[2], Shoichiro Yokota[3] (1.Tokai University, 2.ISAS, 3.Osaka University)

[PCG21-P10] Construction of impact testing machine for small satellites and evaluation of mechanical resistance of MCPs by the impact test

*Junya Fukuba[1] (1.Graduate school of Tokyo)

[PCG21-P11] Innovative design of double-shell type energy analyzer for simultaneous electron and ion measurements in space

*Tomomi Takei[1], Masafumi Hirahara[1] (1.Institute for space-earth environmental research, Nagoya university)

[PCG21-P12] Microsatellite Development and Education of Space Science and Technology at Kanazawa University

*Tomohiko Imachi[1], Satoshi Yagitani[1], Daisuke Yonetoku[1], Yoshiya Kasahara[1], Tatsuya Sawano[1], Makoto Arimoto[1], Yoshitaka Goto[1], Mitsunori Ozaki[1], Ryuichi Fujimoto[1] (1.Kanazawa University)

[PCG21-P13] Attitude Control System for Kanazawa-SAT3 Microsatellite

Takuya Nakajima[1], Yuuki Yasuda[1], Hirofumi Segawa[1], *Tomohiko Imachi[1], Satoshi Yagitani[1], Yoshiya Kasahara[1], Daisuke Yonetoku[1], Tatsuya Sawano[1], Makoto rimoto[1] (1.Kanazawa University)

[PCG21-P14] Communications System and Antennas for Kanazawa-SAT3 Microsatellite

Teruya Minamoto[1], Koyo Ina[1], Kohei Kawagoshi[1], *Tomohiko Imachi[1], Satoshi Yagitani[1], Yoshitaka Goto[1], Daisuke Yonetoku[1], Yoshiya Kasahara[1], Tatsuya Sawano[1], Makoto Arimoto[1] (1.Kanazawa University)

[PCG21-P15] Development of micrometeoroid impact sensor within a multi-layered insulation (CLOTH) onboard 6U deep-space explorer EQUULEUS

*Takayuki Hirai[1], Hajime Yano[2], Ritsuko Jitsukawa[3], Eigo Ishioka[3], Haruki Nakano[3], Kazuyoshi Arai[3], Sunao Hasegawa[2] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Faculty of Science and Engineering, Hosei University)

[PCG21-P16] Breadboard model of asteroid tracking system for DESTINY$^+$ mission

*Peng Hong[1], Ko Ishibashi[1], Shunsuke Sato[2], Kazutoshi Takemura[3], Kotaro Fujiwara[4], Kanako Machii[5], Hiroyuki Toyota[2], Kazutaka Nishiyama[2], Masatsugu Otsuki[2], Osamu Okudaira[1], Takeshi Takashima[2] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Department of Applied Mechanics, Graduate School of Fundamental Science and Engineering, Waseda University, 4.Division of Mechanical and Space Engineering, Graduate School of Engineering, Hokkaido University, 5.Department of Mechanical Engineering and Intelligent Systems, Faculty of Informatics and Engineering, The University of Electro-Communications)

[PCG21-P17] Development of telescopic camera (TENGOO) performance evaluation device in MMX

*Hiroki Kato[1], Shingo Kameda[1], Keigo Enya[2], Osada Naoya[1] (1.Rikkyo University, 2.Japan Aerospace Exploration Agency)

[PCG21-P18] Observation Plans in the Cruising-Phase of the Solar Power Sail: OKEANOS

*Takahiro Iwata[1], Shuji Matsuura[2], KOHJI TSUMURA[3], Hajime Yano[1], Takayuki Hirai[4], Ayako Matsuoka[1], Daisuke Yonetoku[5], Tatehiro Mihara[6], Tatsuaki Okada[1], Osamu Mori[1], Toshihiro Chujo[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2.Kwansei Gakuin University, 3.Tohoku University, 4.Chiba Institute of Technology, 5.Kanazawa University, 6.RIKEN)

Visible and ultraviolet imagers for auroral and airglow observations by FACTORS - a future satellite mission for understanding the coupling and transportation processes in the upper atmosphere

*Takeshi Sakanoi[1], Masafumi Hirahara[2], Takuo T. Tsuda[3], Kazushi Asamura[4], Yoshizumi Miyoshi[2], Tomo-Hiko Watanabe[5], Takanori Nishiyama[6], Shin-ichiro Oyama[2,7], Yoshifumi Saito[4], Keisuke Hosokawa[3], Hirotsugu Kojima[8], Naritoshi Kitamura[9], Yasunobu Ogawa[5], Masatoshi Yamauchi[10], Ayako Matsuoka[4], Naoshi Yagi[1], Fukizawa Fukizawa[1], Genki Ishizawa[11]

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We report science subject, design, development plan and identification of issues to be solved on the visible and ultraviolet imagers for a future satellite mission called FACTORS that aims to understand the coupling processes in the terrestrial magnetosphere/ionosphere/thermosphere and the acceleration and transportation of the space plasma and neutral atmospheric particles. FACTORS stands for Frontiers of Formation, Acceleration, Coupling, and Transport Mechanisms Observed by Outer Space Research System that is proposed as a multi-satellite formation flight mission. This will be a community exploration mission in Japanese apace research after the success of the ERG mission. The working group was approved by ISAS, JAXA this year, and we have started the discussion on detailed science targets, instrumental design, feasibility and so on. We mainly concern on visible and ultraviolet remote imaging of aurora and airglow for this mission. A visible imager (VISAI) on FACTORS will measure small-scale auroral structures at a wavelength of auroral prompt emission line, such as N2 1st PG, with high-time (~0.1s) and high-spatial (~1km) resolutions using a science CMOS or EMCCD. The FOV of 8 x 8 deg covers an area of 400 x 400 km viewed from 3000 km altitude. The high-spatial and high-time resolution imaging data is essential to understand small-scale variations of Alfven aurora, pulsating aurora, etc. Combined with particle and electric/magnetic field data by FACTORS, we will reveal the time and spatial variations of acceleration/scattering process in the complicated magnetosphere-ionosphere coupling system. A far-ultraviolet imager (FUVI) adopts a wide (~40 x 40 deg.) FOV objective mirror system which covers ~2500 x 2500 km area viewed from 3000 km altitude. We plan to adopt a filter wheal in FUV imager to change the wavelength between O 135.6 nm and the N2 LBH band at 140-160 nm. Wide-field multi-wavelength FUV images enable us to examine large-scale auroral dynamics like westward-travelling surge during substorm, omega-bands, and provide us to understand the global thermospheric activity from O/N2 airglow ratio. This year we plan to carry out specific studies for CMOS/EMCCD detectors suited for this mission, and perform radiation tests of detectors.
Related to the future FACTORS mission, we are now carrying out the developments of aural cameras for two sounding rocket projects, G-CHASER (Rocksat-XN) and LAMP. The G-CHASER (Rocksat-XN) rocket was successfully launched from Andøya, Norway on January 13, 2019. We installed an auroral camera (AIC) on this rocket to measure N2 1st PG emission with wide-angle FOV lens(96x75 deg), RG-665 filter, and CCD (WAT-910HX). In addition, we are developing two CMOS cameras AIC2 on the LAMP rocket that is scheduled to be launched at Poker Flat Research Range in winter of 2019. AIC2 will be installed on a despun platform to derotate rocket spin. One CMOS camera AIC2-S1 measures N2 1st PG emission with a narrow FOV lens (F-number=0.95, f=17mm, FOV=27x27deg.), and another CMOS camera AIC-S2

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measures OI 844.6nm emission with a wide-angle lens (F-number=1.6, f=3.5mm, FOV=120x120deg.). Both cameras adopt the ZWO ASI 180 MM CMOS detector. AIC2-S1 will take fine structure of PsA in the region more than 100 x 100 km area around the magnetic footprint with a few kilo-meter resolution, while AIC2-S2 will obtain an altitude distribution of pulsating aurora in the F-region as well as distribution of PsA in wide-range. The precise imaging and altitude distribution of PsA are obtained with AIC2 at two wavelengths with 10Hz sampling. The imaging data combined with precipitating electron data in the wide energy range enable us to investigate the relativistic electron precipitation called microbursts that is probably caused by chorus waves in the magnetosphere.

Keywords: magnetosphere, aurora, imager, ultra violet, visible, ionosphere

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Spatio-temporal analysis of flash aurora using Convolutional Neural Network

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High energy electrons in the magnetosphere travel along geomagnetic field lines and precipitate into the Earth's atmosphere, then auroras are shown on the ground. We can investigate indirectly the behavior of precipitating electrons in the magnetosphere by deducing auroras on the ground. We focus on flash auroras, which illuminate suddenly at less than 1 s. It is difficult to detect a lot of flash aurora events by visually looking because the duration of flash aurora is very short. In this study, we developed an automatic detection of flash auroral position using Convolutional Neural Network (CNN) and performed statistical analysis of the spatio-temporal variations of flash aurora taken by an EMCCD camera (100 Hz sampling, 256 * 256 pixels) at Gakona (Alaska).

The learning data was obtained by dividing the keogram images (2400 * 720 pixels, 1-minute period) along the north-south direction of all-sky EMCCD data into square blocks (30 * 30 pixels, 750-ms period), then the learning data was visually classified to four classes. Four classes are, "pulsating aurora", "flash aurora", "noise", and "no aurora or noise". We classified the test data using the CNN, its accuracy was 91.2%.

The flash aurora data (about 100 events) are collected by CNN and we extracted flash auroral region using Otsu's method, which is a basic method of contour extraction. We performed statistical analysis about luminous duration, luminous point, spatial size, and spatial extent of flash aurora. The averaged luminescence duration was 0.21±0.08 seconds, and did not depend on magnetic longitudes and latitudes in the field-of-view of camera. We confirmed that most events (about 70%) expand earthward with an average spatial extent of 0.027 Re. We think that the earthward extension can be caused by wave propagation effects of whistler mode waves and the nonuniformity of spatial distribution of loss cones in the magnetosphere.
In this presentation, we will report on our automatic detection method and statistical results of spatio-temporal analysis of flash aurora in detail.

Keywords: Convolutional Neural Network, pulsating aurora, flash aurora

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Study on the pulse noise removal technique for Pc1 geomagnetic pulsations on the ground by signal processing

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An electromagnetic ion cyclotron (EMIC) wave, which is a type of plasma waves generated in the magnetosphere, propagates along the geomagnetic field line and we can observe it as the fluctuation in the geomagnetic field on the ground called Pc1 geomagnetic pulsation (0.2 to 5 Hz). We observe Pc1 pulsations at Kapuskasing (Canada). The ground observation is carried out using an induction magnetometer, and the Pc1 pulsations are observed with a high sensitivity and a high time resolution (64 Hz). However, when the observation instrument vibrates due to a strong wind, pulse noise is included in the observed waveforms.
We have been studying an extracting method of Pc1 pulsation by removing the pulse noise included in observed waveform using signal processing technique. Pulse noise shows in a wider frequency range (0.1 to 10 Hz) than the frequency range of Pc1 pulsation and its duration is shorter than the duration of Pc1 pulsation. Pulse noise removal consists of detecting the pulse noise candidate, classifying the pulse noise candidates into pulse noises and others by Neural Network (NN), and interpolating the waveform at the pulse noise domain. In the first step, we set an amplitude threshold for the differential waveform to detect pulse noise candidates. In the second step, as learning data for classification, we use waveform applied a High Pass Filter (HPF) to emphasize pulse noises. In the third step, we use an average energy around the pulse noise in the interpolation. We use random phase, observation phase including the pulse noises, and estimated phase by nonlinear least squares method. For each phase, we evaluated the SNR before and after the pulse noise removal. As a result, the SNR improved with 22dB using the estimated phase, but it requires a huge calculation time.
In this presentation, we will report on the pulse noise removal of Pc1 pulsation using signal processing technique in detail. Conventionally it was necessary to examine and construct the observation environment which suppresses the vibration of the observation equipment as much as possible, we think that our signal processing will be useful for reducing the ground observation costs and a more detailed analysis of Pc1 pulsation.

Keywords: Pc1 geomagnetic pulsation, Noise removal, Signal processing

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Application of magneto-impedance sensor to geomagnetic field measurements

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Magneto-impedance (MI) effect was discovered about 25 years ago and a micro-size magnetic sensor that utilizes this effect becomes commercially available. We made some modifications to the commercially available MI sensors as they can cover the range of the geomagnetic field. For the period of March 30 to April 27, 2018, we conducted experimental observations of geomagnetic field variations with the MI sensors at Mineyama observation site, which is located about 100 km north-west of Kyoto. Data obtained with the MI sensors were compared with those from the fluxgate magnetometer that has been working at the site. Results showed that the MI sensor recorded geomagnetic variations with amplitudes of ~1 nT that were also detected with the fluxgate magnetometer. This suggests that MI sensors are useful for researches in geomagnetism or space physics, although they are much less expensive than fluxgate magnetometers.

We consider developing two different kinds of systems to measure the geomagnetic field using the MI sensor: a system for ground-based observation and a system for a sounding rocket. In presentation, we will display observation data from the MI sensors and the fluxgate magnetometers at Mineyama and other observatories. Future plans of the system onboard sounding rocket will be also presented and discussed.

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Observation of the Ionospheric Currents by the CubeSat at the Low and Middle Latitude

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The ionospheric currents flowing in the dayside ionosphere have been considered as a significant subsequence of Mesosphere-Ionosphere-Magnetosphere coupling. These currents were well detected in the Solar quiet conditions and named Sq currents. In particular, it is well known that the flow pattern of Sq currents shows the north-south hemispheric asymmetry due to the different ionospheric conductivities in the winter and summer hemispheres. This indicates that the asymmetry of the potential must be kept by the energy balance between each hemisphere through the field line.
An InterHemispheric Field Aligned Current (IHFAC) was theoretically predicted by Maeda [1974] and Fukushima [1979, 1991] to interpret the north-south asymmetry in the potential pattern. Several ground magnetic observations and satellite observations suggested an existence of the IHFAC in the noon sector and both the morning and evening terminators. However, the detailed morphology of the IHFAC have not been well understood yet, despite that the direct detection of the IHFAC at Low Earth Orbit (LEO) was reported in the observation by several satellites.
In order to investigate the Sq current system including the IHFAC, the in-situ observation by a CubeSat (2U size satellite emitted from ISS) is proposed in collaboration with 10 national colleges which belong to National Institute of Technology (KOSEN). The fluxgate magnetometer is onboard the CubeSat to observe small perturbations of the magnetic field. After the ejection from the ISS, the CubeSat will gradually glide down to the upper atmosphere due to the strong atmospheric drag and finally burn up in it. The duration of possible observation is estimated for more than 50 days.
The CubeSat can be characterized by the short duration of development (less than 3 years) and low cost (less than 100,000USD). We are considering an actual utilization of this extremely low-cost CubeSat to more realistic science mission. This concept enables us to conduct the multi-satellite in-situ observation in fairly low budget compared to conventional satellite missions.

Keywords: Ionospheric Current, Interhemispheric Field Aligned Current, CubeSat

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Basic study on miniaturization of electric field instrument for plasma wave observations by ASIC technology

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We have been measuring electric fields of the plasma waves (a few Hz to several hundred Hz) to understand the magnetospheric dynamics. The spatial resolutions of electric field measurements are not enough because we cannot launch a lot of satellites due to the large size and mass of satellites. Demands of micro satellites like a 1U (10 cubic centimeters) cube satellites are increasing. We need to miniaturize measurement instruments for probing the plasma waves.

This study deals with an electric field instrument in plasma wave observations. We use the electric field instrument for capturing the electric fields detected by wire probe antennas. In this study, the purpose is to miniaturize the electric field instrument with a high radiation tolerance (300 krad) using Application Specific Integrated Circuit (ASIC) technology.

We designed a based amplifier for a new electric field instrument. In the new based amplifier, the equivalent input noise is 50 nV/sqrt(Hz) at 1 kHz, which is 3.9 dB-larger than that of conventional based amplifier (OP-41). The noise performance of new based amplifier is acceptable for capturing the plasma waves. To confirm the radiation tolerance of new based amplifier, we did the radiation tests up to 300 krad using the gamma ray. From the radiation test results, the gain was no change before and after the radiation tests. The output noise was degraded with 5.05 dB at 100 Hz by total ionizing dose effects. However, the based amplifier was not breakdown by the gamma ray. The electric field instrument consisted of new based amplifier could operate with a high radiation tolerance.

We conducted the transient analysis for the new electric field instrument by a circuit simulator (Tanner EDA). In the simulation, rectangular waves of 1 Vpp with 10 Hz input to the new electric field instrument via a sheath impedance (10 MOhms and 100 pF). From the simulation results, the output waveforms of new electric field instrument showed similar output waveforms in comparison with the conventional electric field instrument. The power consumption of new electric field instrument can decrease with approximately 67% than that of the conventional electric field instrument. From the simulation results, we confirmed the basic operations as the electric field instrument for detecting the plasma waves. In the future work, we will need to improve the temperature operating range because the new electric field instrument cannot operate at minus 60 Celsius degrees from the temperature simulation results.

In this presentation, we will present the basic study on electric field instrument for plasma wave observation by ASIC technology in detail.

Keywords: ASIC, Electric field instrument, Plasma wave observation

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Evaluation of radiation tolerance of electronics parts used for the ultra-small mission

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In the space environment, spacecraft is exposed to radiation and degrades the data. For example, the increase of dark current, and change in current consumption.

Recently, the university-made ultra-small spacecraft mission become popular. The mission in this class can reduce the cost and time by using commercial products. However, these commercial products are thought to have no radiation tolerance. Then, it is necessary to be tested with the radiation total dose which is calculated using the Monte Carlo simulation.

We are developing the extreme ultraviolet imager PHOENIX onboard the ultra-small satellite EQUULEUS which will be launched in 2020. Helium ions in the Earth’ s plasmasphere emit extreme ultraviolet light (wavelength of 30.4 nm) through the solar resonance scattering. PHOENIX observes them from the moon (Earth-Moon L2 point).

The radiation tolerance has been evaluated with a gamma irradiation facility with cesium 137. In this presentation, we show the gain characteristics and change of electric noise with respect to radiation of semiconductor elements used in PHOENIX instrument.

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A method to quantitatively evaluate Non-evaporable-getter pump for use in space science mission

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Observation instruments are known to deteriorate under atmospheric condition. Deterioration are mainly caused by reaction with water vapor and oxygen. To prevent this, observation instruments must be maintained under vacuum. The problem is that the conventional vacuum pump are too heavy to carry to the launching site. The need of continuous power supply makes the transport more difficult. Also the vacuum pump must be removed before the launch. These problems are not only making it difficult to maintain observation instruments under vacuum but also causing extra costs. Non-evaporable-getter (NEG) pumps are able to solve these problems. NEG pumps are light weight, compact, oil free, vibration free, and able to operate without energy supply after activation. Considering the utilization of NEG pump for space science missions, we need to quantitatively evaluate the NEG pump to optimize its size, shape, material, and mounting position for each mission. In this study, a method to measure pumping speed of NEG pump for carbon monoxide (as substitute to water vapor and oxygen) was established by using the orifice method. By using this method, it will be able to develop a NEG pump which best applies the case for each mission.

Keywords: Non-evaporable-getter pump, vacuum pump

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Interpretation on slight asymmetry of analyzer characteristics of MIA onboard the Mio by means of a model calculation of 3-D potential distribution

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MIA (Mercury Ion Analyzer) on board Mio employs a top-hat electrostatic analyzer, which has axisymmetric toroidal electrodes and is designed to have no dependence in its characteristics on azimuthal direction of incident ions. However, our ground calibration experiments have revealed that it has a slight dependence. We have tried to explain the dependence by means of three dimensional model calculations. We assumes that all parts of electrode are manufactured precisely. Our results shows that a slight relative rotation (or tilt) of electrodes can lead to a slight dependence on incident azimuthal direction similar to that obtained from the ground experiments.

Keywords: Mio, tophat electrostatic analyzer , MIA

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Construction of impact testing machine for small satellites and evaluation of mechanical resistance of MCPs by the impact test

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Small satellites have been developed in recent years. Environmental tests at the development stage play an important role in improving reliability of small satellites. These include a vibration test, an impact test, and a thermal vacuum test. Especially, the impact test is one of the most difficult tests and a reliable method has not yet been established. Against such a background, we constructed an impact testing machine for small satellites. Required performance of the impact testing machine is a controllability and a reproducibility. The controllability means the performance of applying a targeted impact level accurately. This is important to avoid applying excessive impacts on a test target. The reproducibility means the performance of applying same impact level repeatedly and this is also important because if it is possible to apply an unintended impact under the same condition, it degrades the test accuracy. Our impact testing machine is designed to be able to easily adjust the impact level and have high reproducibility. Furthermore, we tested for mechanical resistance of the MCP (micro-channel plate) which is used for optical observation instruments. In this test, we used an impact level assuming the EQUULEUS mission which will be launched by NASA’ s rocket in 2020. In my presentation, I will introduce the details of our impact testing machine and the impact test results of MCP.

Keywords: impact test

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Innovative design of double-shell type energy analyzer for simultaneous electron and ion measurements in space

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It is well known that the terrestrial and planetary magnetospheres and the interplanetary space are filled with charged particles such as electrons and ions, which are so-called the space plasma, and in-situ observations of the space plasmas have been conducted by using satellites carrying particle instruments, such as the top-hat type electrostatic energy analyzer. Essentially, obtaining three-dimensional velocity distributions of the space plasmas or energy-pitch angle distributions help us understand the dynamics of the space plasmas. Because the top-hat type analyzer is cylindrically symmetric and has a 2π-radian planar field of view, it can independently measure the wide angular and energy distributions of incident particles. Also, three-dimensional velocity or energy-pitch angle distributions can be obtained by utilizing the satellite spin motion.
The top-hat type electrostatic energy analyzers can measure the ions when a negative potential is applied to the inner electrode and the electrons by a positive potential with the outer electrode grounded. Therefore, in the prevailing design of the top-hat type analyzer, the sensor heads separate for the ion and electron observations, respectively. Because of the recent miniaturization of the satellites, the weight and space of the instruments mounted on the small and micro satellites are getting severely restricted. However, if two sensors for electron and ion observations are combined into one sensor head, it is possible to save both weight and space on the small and micro satellites. Therefore, we have been developing double-shell type energy analyzer which can simultaneously measure the ions and the electrons with one sensor head.
We designed the shapes of the collimator and the double-layered dome-shaped electrodes so that the electrons and the ions with appropriate energies pass through the inner gap and the outer gap by applying a negative potential to the central electrode with the inner and outer electrodes grounded, respectively. We made the numerical simulations using SIMION which is a charged particle simulator program and investigated the performance and characteristics as the electrostatic analyzer. Consequently, we confirmed that the electrons and the ions can be analyzed with one sensor head by only applying negative high voltage to the electrodes. So far, we consider the detection unit using Time-Of-Flight velocity spectrometer for the discrimination of the ion species as the part where the ions are detected, and an assembly of micro channel plates is expected for the electron detection. The design of TOF-type mass analysis unit as ion mass analysis unit is one of subjects for future work.

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Microsatellite Development and Education of Space Science and Technology at Kanazawa University

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1. Kanazawa University

At Kanazawa University, researchers from engineering and science are cooperating to promote the "Kanazawa University Satellite Project (Kanazawa-SAT3: Study and Training in Space Science and Technology for Kanazawa Cube-Satellites)". In this project, a microsatellite is being developed by staff and students of Kanazawa University. It is a scientific satellite which will contribute to the elucidation of the mechanism of gravitational wave generation by identifying the source of gravitational wave by detecting the arrival direction of gamma rays and X rays radiated at the same time when a gravitational waves are generated by collision of astronomical objects The satellite will be inserted into a solar synchronous orbit at about 660 km altitude. It is a microsatellite with a total weight of 50 kg or less, and its size is cubic with a side of 50 cm, and it is designed to be a piggyback on an HII-A rocket.

Also related to this project, a space science and engineering course has been newly established in the Graduate School of Natural Sciences in April 2018. This course is based on the 'satellite development by students', and students are actually involved in the design, fabrication, ground tests, and operation of scientific satellites, aiming to train personnel who are familiar with space science and space engineering, with satellite-development skills.

Ground tests with the thermal and structural model of Kanazawa-SAT3 have been completed , and the unit tests for almost all components are being conducted. Currently, we are completing the design of the flight model. In the presentation, we will report the details of Kanazawa-SAT3 and its development status.

Keywords: Microsatellite, Gravitational wave, Kanazawa SAT3

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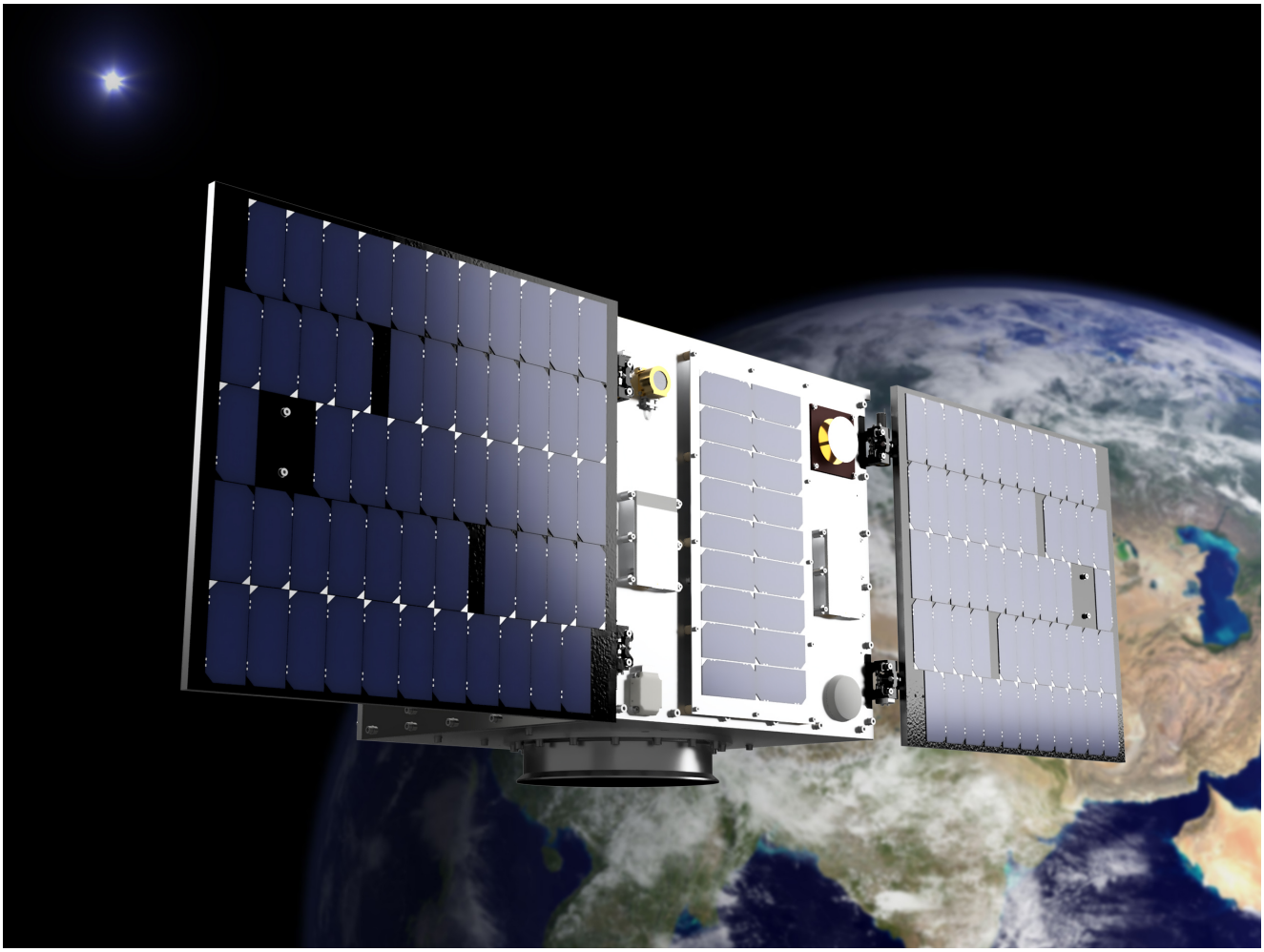

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Attitude Control System for Kanazawa-SAT3 Microsatellite

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1. Kanazawa University

Kanazawa University has been developing a microsatellite. This satellite is equipped with a device to observe celestial bodies emitting gravitational waves with X rays, and aims to elucidate the mechanism of black hole formation by estimating the time of arrival and direction of arrival of gravitational waves.
In this research, the attitude control system is being developed using GAS (Geomagnetic Aspect Sensor) and MTQ (Magnetic Torque). We have constructed the environment for the unit test of RW (Reaction Wheel) also used for attitude control of the satellite.

MTQ is a device that controls the attitude of the satellite by generating a magnetic torque against the geomagnetic field by applying a voltage (an electric current) to a magnetic coil. GAS is a device for detecting the direction of the geomagnetic vector. OBC (On Board Computer) which controls all devices mounted on the satellite receives the geomagnetic field data detected by GAS, and transmits commands to control MTQ. GAS and MTQ cannot be connected to OBC directly, because OBC has just a digital interface, but the output of GAS and the input to MTQ are analog voltages. Therefore, we have developed a control device for on-board equipment using a microcontroller. For the GAS, the voltages are A/D-converted by the microcontroller and transmitted to the OBC. For the MTQ, OBC transmits control commands to the microcontroller, which generates a PWM (Pulse Width Modulation) signal according to the received command that determines the effective voltage to be given to the MTQ. For the system development and operation tests, a PC is used instead of OBC and we carried out experiments of control equipment. For the GAS, we have confirmed the linearity between the analog magnetic field and the corresponding digital values transmitted to the PC. For the MTQ, we have confirmed that the voltage to be given to MTQ were precisely controlled by the duty ratio of the PWM signal output from the microcontroller.

RW is a device to generate a control torque around the rotation axis by accelerating a rotor by a motor and is controlled by transmitting a command from the OBC via an RS-422 serial communication line. The unit test has been carried out by using a PC as a substitute of OBC, but the cable had a influence on the rotation operation of RW. Therefore, we have constructed a system for wirelessly connecting the RW with the PC via a wireless RS-422 communication. Specifically, commands from the PC are wirelessly transmitted to an Arduino microprocessor by a low-power radio module XBee, and the RW is controlled via an RS-422 transceiver. With this system, we demonstrated the basic functions for command and data between the PC and the Arduino via the wireless RS-422 transceiver.

We plan to construct a system that applies appropriate PWM signals to MTQ according to the value detected by GAS. We will also evaluate RW performance by the unit test using the wireless RS-422 communication system.

Keywords: Microsatellite, ACS, Kanazawa SAT3

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Communications System and Antennas for Kanazawa-SAT3 Microsatellite

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1. Kanazawa University

Kanazawa University is developing the first Kanazawa University's microsatellite, named as Kanazawa-SAT3. Kanazawa-SAT3 is planned to be launched within FY2019, and its observation mission is to identify the source of gravitational waves by detecting the occurrence time and arrival direction of the X-rays and gamma rays observed simultaneously with gravity waves from distant astronomical objects.

In this research, we are developing a communications system for Kanazwa-SAT3. Kanazawa-SAT3 has three different communication systems using S band, UHF band and Iridium, and the link design of each of them has generally been completed. We summarize each communication system in detail as the following.

The S-band communication system, will use 2-GHz frequency band. Kanazawa-SAT3 is equipped with two types of antennas: S-band patch antennas and S-beacon antennas. S-band system is a main communication system between the satellite and a ground station, and plays a role of high speed data communication and beacon transmission. On the satellite side, two S-band patch antennas designed for both transmission and reception are mounted on the front and rear panels of the satellite. Two S-beacon antennas for transmission are also mounted on the front and rear panels of the satellite. On the ground side, we will send and receive by the signals using a 2.4-m parabolic dish installed at Kanazawa University.

The UHF communication system will use 400-MHz frequency bands. This system transmits commands from the ground to the satellite and telemetry information from the satellite to the ground. On the satellite side, four inverted-F type antennas we developed are mounted (two for receiving and two for transmitting) on the front and rear panels of the satellite. On the ground side, we will send and receive data by using a Yagi antenna with 14 crossed elements installed at Kanazawa University. We have also constructed an automatic satellite tracking system using the Yagi antenna.

A communication system using the Iridium satellite network uses a frequency band around 1.6 GHz. In this system, communications are performed via Iridium satellite, so that the communication can be established even when our ground station is not visible from the satellite. The data is exchanged between the satellite and the ground by using e-mail. This system can transmit and receive data in almost real time so emergency command and data transmission will be available. On the satellite side, two antennas for both transmission and reception are mounted on the front and rear panels of the satellite. A system has been constructed that exchanges data between a laptop computer simulating an onboard computer (OBC) mounted on a satellite and an iridium satellite.

From now on, for the communication systems using the S band and the UHF band, it is necessary to develop the communication software. For In addition, we need to improve the automatic satellite tracking system of Kanazawa-SAT3. For the communication system using Iridium satellite, it is necessary to implement a system on the OBC and conduct a communication experiment.

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Keywords: Microsatellite, Communications System, Kanazawa SAT3

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Development of micrometeoroid impact sensor within a multi-layered insulation (CLOTH) onboard 6U deep-space explorer EQUULEUS

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In recent years, the use of CubeSat for deep-space exploration is remarkably expanding. Equilibrium Lunar-Earth point 6U Spacecraft (EQUULEUS) project led by the University of Tokyo and JAXA is one of 13 sub payloads which will be launched by the NASA’ s new rocket, Space Launch System (SLS) in 2019 or later. In addition to the engineering mission of orbital maneuvering, EQUULEUS will perform 3 scientific missions consisted of geo-corona, lunar impact flash, and micrometeoroid observations on the way to the Earth-Lunar libration point 2. Our Cis-Lunar Object detector within THermal Insulation (CLOTH) is a piezoelectric film sensor integrated with the EQUULEUS’ s multi-layer insulation (MLI). CLOTH can detect micrometeoroid which impacts and penetrates the outermost layer of EQUULEUS's MLI. The space flight demonstration of CLOTH will expand the possibility of deep-space exploration by CubeSat. In this presentation, we introduce the concept of CLOTH, i.e. micrometeoroid detector integrated with a spacecraft bus component, and the detection performance estimated by hypervelocity microparticle impact test on the ground.

Keywords: Piezoelectric film, PVDF, Thermal insulation, CubeSat, Micrometeoroid, Hypervelocity impact

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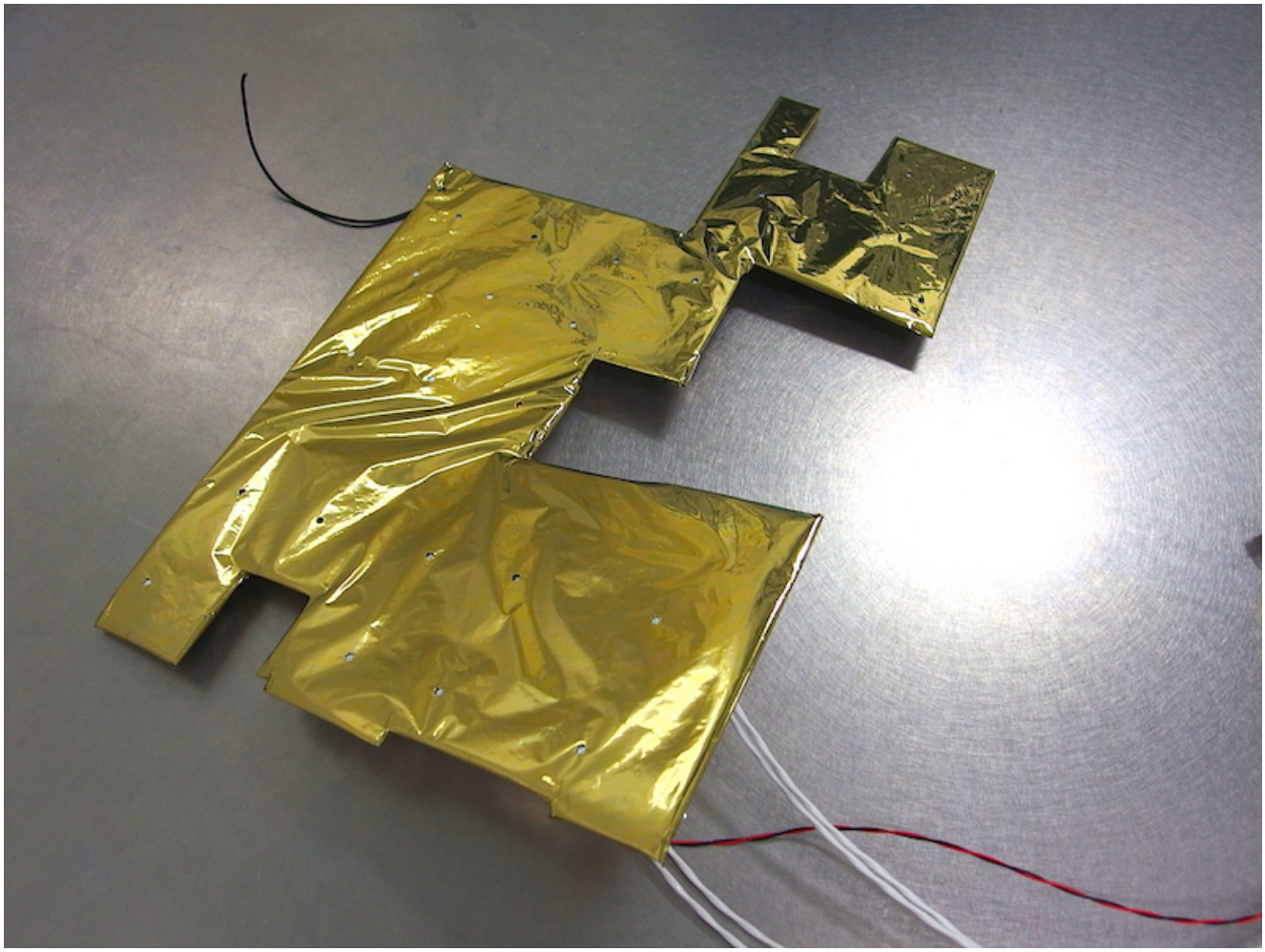

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Breadboard model of asteroid tracking system for DESTINY^{+} mission

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DESTINY^{+} (Demonstration and Experiment of Space Technology for Interplanetary voYage, Phaethon fLyby and dUst Science) is a mission proposed for JAXA/ISAS Epsilon class small program, currently in the pre-project phase (Phase-A) with a launch targeted for 2023. The mission plans to conduct high-resolution imaging during close flyby of asteroid (3200) Phaethon, which is considered as a parent body of Geminid meteor shower. Two cameras are planned to be onboard DESTINY^{+}, the Telescopic Camera for Phaethon (TCAP) and the Multiband Camera for Phaethon (MCAP). While MCAP is designed for low spatial resolution imaging, TCAP is planned to perform high-resolution imaging, especially from ~40 seconds before to ~9 seconds after the closest approach with an imaging rate of more than 1 frame per second and the surface of Phaethon will be imaged with a spatial resolution up to 3.5 m/px at closest approach. Both cameras will be mounted and installed on the wall of spacecraft bus, thus orientations of the cameras are mainly controlled by the attitude of spacecraft. However, since the relative flyby speed and closest distance to Phaethon are expected to be 30 to 40 km/s and about 500 km, it is significantly difficult to track the asteroid only by the rotation of the spacecraft itself. Therefore, an asteroid tracking system is required for TCAP to obtain unblurred high-resolution images. The tracking system is also required to operate autonomously during the high-speed flyby. We have conducted conceptual studies of the tracking mirror as well as control algorithms to properly navigate the mirror based on feedforward or feedback loop. To realize the designed concept, we have developed a simple breadboard model focusing on the rotating mechanism which is the most important part of tracking mirror. The breadboard model consists of a rotating mirror, a 2-phase stepping motor and its driver, a motor reducer, and a FPGA board to control the driver. Required performances for the breadboard model of tracking system are (1) the rotating mirror should be able to orient a desired direction with an enough accuracy, (2) the mirror should be able to rotate smoothly with an enough accuracy during the exposure of TCAP. We will report the current development status of breadboard model of asteroid tracking system for TCAP and show its initial results of the performance test.

Keywords: DESTINY+, camera, flyby, tracking system

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Development of telescopic camera (TENGOO) performance evaluation device in MMX

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Mars has two satellites, Phobos and Deimos, and there are currently two hypotheses for the origin of these satellites. The first of these hypotheses is that the moons are captured primitive asteroids, and the second is that they formed because of a giant impact event on Mars. The Japan Aerospace Exploration Agency (JAXA) is planning the Martian Moon eXploration (MMX) mission, which is a sample-return mission for Phobos, to determine which hypothesis is correct and reveal the origin of these two satellites.

The TElescopic Nadir imager for GeOmOrphology (TENGOO), which will be installed in MMX, has the purpose of measuring the geographical features of Phobos to locate a suitable landing site less influenced by space weathering. The design of TENGOO was optimized for achieving this goal. In the optical design, the instantaneous Field of View (iFoV) is 5.8 μrad/pix and the Modulation Transfer Function (MTF) is 0.3 at the Nyquist frequency.The design performance of the manufactured TENGOO needs to be confirmed. We evaluate the performance of TENGOO by measuring the Point Spread Function (PSF). Therefore, a low divergence collimated light is needed for a ground experiment to obtain the PSF with sufficient accuracy. We succeeded at making a collimated light source with divergence less than 11.6 μrad.

The Full Width of Half Maximum (FWHM) of PSF obtained with this collimated light is approximately 2x2 pixels in TENGOO. Therefore, the sampling interval becomes wider than FWHM of PSF, and the error of PSF estimation due to Gaussian fitting increases. To solve this problem, we measured the Line Spread Function (LSF) with diagonal lines and complemented the measuring points by obtaining multiple PSFs.

Keywords: Mars, MMX, camera

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Observation Plans in the Cruising-Phase of the Solar Power Sail: OKEANOS

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The solar power sail mission: OKEANOS (Oversize Kite-craft for Exploration and AstroNautics in the Outer Solar system) is a Japanese candidate deep-space probe that will be powered by hybrid propulsion of solar photon acceleration and ion engines. The main scientific objectives are studies of Trojan asteroids in the Jovian L4 or L5 regions. The long distance and period from the launch to the swing-by at Jupiter will give us a good opportunity to explore the solar system between the Earth and the Jupiter to elucidate the solar system disc structure. We define the cruising-phase sciences of the OKEANOS mission as the scientific theme that will be explored or observed from the launch to the swing-by at Jupiter. Candidates of instruments for the cruising phase are: the EXo-Zodiacal Infrared Telescope (EXZIT), the Arrayed Large-area Dust detectors in INterplanetary space (ALADDIN)-2, the MaGnetic Field experiment (MGF), and the GAmma-ray burst Polarimeter (GAP)-2. In this paper, we report scientific purpose and observation plans of them.

Zodiacal light observed at visible and near-infrared wavelengths is thought to be sunlight scattered by interplanetary dust. The two-dimensional distribution of zodiacal light reflects the three-dimensional structure of interplanetary dust. However, it is still controversial that how the ratio of asteroid-origin to comet-origin changes by the heliocentric distance. Therefore, the comparison of the radial distribution of zodiacal light and the in-situ dust observation will help clarify the distribution and components of solid particles in our solar system. These results are expected to provide precise distribution of the interplanetary dust in our solar-system discs.
The temperature of the solar wind, which depends on the heliocentric distance, has been observed to be greater than that predicted by the adiabatic model. Therefore, the existence of heating processes, such as plasma turbulence or magnetic reconnection, could be predicted. The observation of the magnetic field by the devices separated in the scale of the membrane of the Solar Power Sail provides the resolution of the plasma turbulence on the electron scale. Thus, the intermittent observation of the magnetic field between the Earth and Jupiter would determine the heating mechanism of the solar wind. The synergy of the magnetic field and dust observation may show the interaction between interplanetary dust and solar wind. By analyzing the environments on the dust surface, the chemical evolutions of molecules caused by solar wind and cosmic radiation can be investigated. We are investigating the possibilities to detect gamma-rays and particles from the solar-system shocks.

Keywords: OKEANOS, zodiacal light, dust, plasma, gamma-ray

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[E] Poster | P (Space and Planetary Sciences)：P-CG Complex & General

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_8

[P-CG21] Future Missions and instrumentation for space and planetary science

convener:Mitsunori Ozaki(Faculty of Electrical and Computer Engineering, Institute of Science and Engineering, Kanazawa University), Satoshi Kasahara(The university of Tokyo), Shingo Kameda(School of Science, Rikkyo University), Kazuo Yoshioka(Graduate School of frontier Science, The University of Tokyo)

Not only national space agencies but some universities and even companies in the world are now leading a number of space science and exploration missions and also energetically initiating new research activities for satellite and rocket developments and international collaborations in these days because the Earth observations from the space and the space explorations could be achieved much easier than a few decades ago. The deployment to the space, which itself is not purely a scientific purpose but one of methods for better sciences, is vigorously motivating the technical innovation and the educational development. For successful space missions, it is also crucial to research and develop aim-oriented on-board instruments, and the fundamental research and development of observational instrumentation with future perspectives could totally lead space missions in some case. Detailed investigation and evaluation on various on-board instruments are needed during their proposals, selections, and fabrications in order to promote the missions, and inevitably we have to make multi-sided arrangements and evolution at every process and aspect of any type of space missions, independently of their mission sizes. In this session, we focus on these comprehensive research activities in the space and astronomical missions, including the mission integrations and the individual instrumental developments, and we also call many presentations showing the uniqueness and renovation regarding the mission strategy and methodology, and the status and latest results in the related state-of-the-art researches and developments, which would provide all of researchers and developers with invaluable opportunities for active discussion, information sharing, and collaboration toward the realization of more missions for more fruitful space sciences and explorations in nearer future.

[PCG21-P01] Visible and ultraviolet imagers for auroral and airglow observations by FACTORS - a future satellite mission for understanding the coupling and transportation processes in the upper atmosphere

*Takeshi Sakanoi[1], Masafumi Hirahara[2], Takuo T. Tsuda[3], Kazushi Asamura[4], Yoshizumi Miyoshi[2], Tomo-Hiko Watanabe[5], Takanori Nishiyama[6], Shin-ichiro Oyama[2,7], Yoshifumi Saito[4], Keisuke Hosokawa[3], Hirotsugu Kojima[8], Naritoshi Kitamura[9], Yasunobu Ogawa[5], Masatoshi Yamauchi[10], Ayako Matsuoka[4], Naoshi Yagi[1], Fukizawa Fukizawa[1], Genki Ishizawa[11] (1.Planetary Plasma and Atmospheric Research Center, Graduate School of Science, Tohoku University, 2.ISEE, Nagoya University, 3.Graduate School of Informatics and Engineering, School of Informatics and Engineering, The University of Electro-Communications, 4.ISAS/JAXA, 5.Graduate School of Science, Nagoya University, 6.National Institute for Polar Research, 7.University of Oulu, Finland, 8.RISH, Kyoto University, 9.Graduate School of Science, the University of Tokyo, Tokyo, 10.IRF Kiruna, Sweden, 11.Graduate School of Science, Tohoku University)

[PCG21-P02] Spatio-temporal analysis of flash aurora using Convolutional Neural Network

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[PCG21-P03] Study on the pulse noise removal technique for Pc1 geomagnetic pulsations on the ground by signal processing

*Fumiya Komase[1], Tomohiro Inoue[1], Mitsunori Ozaki[1], Satoshi Yagitani[1], Kazuo Shiokawa[2], Masahito Nose[2], Tsutomu Nagatsuma[3] (1.Kanazawa Univ., 2.Nagoya Univ., 3.NICT)

[PCG21-P04] Application of magneto-impedance sensor to geomagnetic field measurements

*Masahito Nose[1], Reiko Nomura[2], Kazushi Asamura[3], Hitoshi Aoyama[4], Takeshi Kawano[4], Ayako Matsuoka[3], Kentarou Kitamura[5], Yukinobu Koyama[6], Haruhisa Matsumoto[7], Masafumi Hirahara[1] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.National Astronomical Observatory of Japan, 3.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 4.Aichi Steel Corporation, 5.National Institute of Technology, Tokuyama College, 6.National Institute of Technology, Oita College, 7.Research and Development Directorate, Japan Aerospace Exploration Agency)

[PCG21-P05] Observation of the Ionospheric Currents by the CubeSat at the Low and Middle Latitude

*Kentarou Kitamura[1], Kazumasa Imai[2], Taku Takada[2], Manabu Shinohara[3], Makoto Wakabayashi[4], KOSEN Space Collaboration Group (1.National Institute of Technology, Tokuyama Collge, 2.National Institute of Technology, Kochi Collge, 3.National Institute of Technology, Kagoshima Collge, 4.National Institute of Technology, Niihama Collge)

[PCG21-P06] Basic study on miniaturization of electric field instrument for plasma wave observations by ASIC technology

*Yuya Tokunaga[1], Mitsunori Ozaki[1], Keigo Ishisaka[2], Hirotsugu Kojima[3], Satoshi Yagitani[1], Takahiro Zushi[3] (1.Kanazawa University, 2.Toyama Prefectural University, 3.Kyoto University)

[PCG21-P07] Evaluation of radiation tolerance of electronics parts used for the ultra-small mission

*Riku Katsuse[1], Kazuo Yoshioka[1], Masaki Kuwabara[2], Reina Hikida[1], Shogo Arao[1], Ichiro Yoshikawa[1] (1.The university of Tokyo , 2.Institute of Space and Astronautical Science)

[PCG21-P08] A method to quantitatively evaluate Non-evaporable-getter pump for use in space science mission

*Seiya Nishimura[1], Ichiro Yoshikawa[1], Kazuo Yoshioka[1], Shogo Arao[1], Zhang Tianxu[1] (1.The university of tokyo)

[PCG21-P09] Interpretation on slight asymmetry of analyzer characteristics of MIA onboard the Mio by means of a model calculation of 3-D potential distribution

*Wataru Miyake[1], Yoshifumi Saito[2], Shoichiro Yokota[3] (1.Tokai University, 2.ISAS, 3.Osaka University)

[PCG21-P10] Construction of impact testing machine for small satellites and evaluation of mechanical resistance of MCPs by the impact test

*Junya Fukuba[1] (1.Graduate school of Tokyo)

[PCG21-P11] Innovative design of double-shell type energy analyzer for simultaneous electron and ion measurements in space

*Tomomi Takei[1], Masafumi Hirahara[1] (1.Institute for space-earth environmental research, Nagoya university)

[PCG21-P12] Microsatellite Development and Education of Space Science and Technology at Kanazawa University

*Tomohiko Imachi[1], Satoshi Yagitani[1], Daisuke Yonetoku[1], Yoshiya Kasahara[1], Tatsuya Sawano[1], Makoto Arimoto[1], Yoshitaka Goto[1], Mitsunori Ozaki[1], Ryuichi Fujimoto[1] (1.Kanazawa University)

[PCG21-P13] Attitude Control System for Kanazawa-SAT3 Microsatellite

Takuya Nakajima[1], Yuuki Yasuda[1], Hirofumi Segawa[1], *Tomohiko Imachi[1], Satoshi Yagitani[1], Yoshiya Kasahara[1], Daisuke Yonetoku[1], Tatsuya Sawano[1], Makoto rimoto[1] (1.Kanazawa University)

[PCG21-P14] Communications System and Antennas for Kanazawa-SAT3 Microsatellite

Teruya Minamoto[1], Koyo Ina[1], Kohei Kawagoshi[1], *Tomohiko Imachi[1], Satoshi Yagitani[1], Yoshitaka Goto[1], Daisuke Yonetoku[1], Yoshiya Kasahara[1], Tatsuya Sawano[1], Makoto Arimoto[1] (1.Kanazawa University)

[PCG21-P15] Development of micrometeoroid impact sensor within a multi-layered insulation (CLOTH) onboard 6U deep-space explorer EQUULEUS

*Takayuki Hirai[1], Hajime Yano[2], Ritsuko Jitsukawa[3], Eigo Ishioka[3], Haruki Nakano[3], Kazuyoshi Arai[3], Sunao Hasegawa[2] (1.Planetary Exploration Research Center, Chiba Institute of Technology, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Faculty of Science and Engineering, Hosei University)

[PCG21-P16] Breadboard model of asteroid tracking system for DESTINY$^+$ mission

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[PCG21-P17] Development of telescopic camera (TENGOO) performance evaluation device in MMX

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[PCG21-P18] Observation Plans in the Cruising-Phase of the Solar Power Sail: OKEANOS

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Visible and ultraviolet imagers for auroral and airglow observations by FACTORS - a future satellite mission for understanding the coupling and transportation processes in the upper atmosphere

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We report science subject, design, development plan and identification of issues to be solved on the visible and ultraviolet imagers for a future satellite mission called FACTORS that aims to understand the coupling processes in the terrestrial magnetosphere/ionosphere/thermosphere and the acceleration and transportation of the space plasma and neutral atmospheric particles. FACTORS stands for Frontiers of Formation, Acceleration, Coupling, and Transport Mechanisms Observed by Outer Space Research System that is proposed as a multi-satellite formation flight mission. This will be a community exploration mission in Japanese apace research after the success of the ERG mission. The working group was approved by ISAS, JAXA this year, and we have started the discussion on detailed science targets, instrumental design, feasibility and so on. We mainly concern on visible and ultraviolet remote imaging of aurora and airglow for this mission. A visible imager (VISAI) on FACTORS will measure small-scale auroral structures at a wavelength of auroral prompt emission line, such as N2 1st PG, with high-time (~0.1s) and high-spatial (~1km) resolutions using a science CMOS or EMCCD. The FOV of 8 x 8 deg covers an area of 400 x 400 km viewed from 3000 km altitude. The high-spatial and high-time resolution imaging data is essential to understand small-scale variations of Alfven aurora, pulsating aurora, etc. Combined with particle and electric/magnetic field data by FACTORS, we will reveal the time and spatial variations of acceleration/scattering process in the complicated magnetosphere-ionosphere coupling system. A far-ultraviolet imager (FUVI) adopts a wide (~40 x 40 deg.) FOV objective mirror system which covers ~2500 x 2500 km area viewed from 3000 km altitude. We plan to adopt a filter wheal in FUV imager to change the wavelength between O 135.6 nm and the N2 LBH band at 140-160 nm. Wide-field multi-wavelength FUV images enable us to examine large-scale auroral dynamics like westward-travelling surge during substorm, omega-bands, and provide us to understand the global thermospheric activity from O/N2 airglow ratio. This year we plan to carry out specific studies for CMOS/EMCCD detectors suited for this mission, and perform radiation tests of detectors.
Related to the future FACTORS mission, we are now carrying out the developments of aural cameras for two sounding rocket projects, G-CHASER (Rocksat-XN) and LAMP. The G-CHASER (Rocksat-XN) rocket was successfully launched from Andøya, Norway on January 13, 2019. We installed an auroral camera (AIC) on this rocket to measure N2 1st PG emission with wide-angle FOV lens(96x75 deg), RG-665 filter, and CCD (WAT-910HX). In addition, we are developing two CMOS cameras AIC2 on the LAMP rocket that is scheduled to be launched at Poker Flat Research Range in winter of 2019. AIC2 will be installed on a despun platform to derotate rocket spin. One CMOS camera AIC2-S1 measures N2 1st PG emission with a narrow FOV lens (F-number=0.95, f=17mm, FOV=27x27deg.), and another CMOS camera AIC-S2

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measures OI 844.6nm emission with a wide-angle lens (F-number=1.6, f=3.5mm, FOV=120x120deg.). Both cameras adopt the ZWO ASI 180 MM CMOS detector. AIC2-S1 will take fine structure of PsA in the region more than 100 x 100 km area around the magnetic footprint with a few kilo-meter resolution, while AIC2-S2 will obtain an altitude distribution of pulsating aurora in the F-region as well as distribution of PsA in wide-range. The precise imaging and altitude distribution of PsA are obtained with AIC2 at two wavelengths with 10Hz sampling. The imaging data combined with precipitating electron data in the wide energy range enable us to investigate the relativistic electron precipitation called microbursts that is probably caused by chorus waves in the magnetosphere.

Keywords: magnetosphere, aurora, imager, ultra violet, visible, ionosphere

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Spatio-temporal analysis of flash aurora using Convolutional Neural Network

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High energy electrons in the magnetosphere travel along geomagnetic field lines and precipitate into the Earth's atmosphere, then auroras are shown on the ground. We can investigate indirectly the behavior of precipitating electrons in the magnetosphere by deducing auroras on the ground. We focus on flash auroras, which illuminate suddenly at less than 1 s. It is difficult to detect a lot of flash aurora events by visually looking because the duration of flash aurora is very short. In this study, we developed an automatic detection of flash auroral position using Convolutional Neural Network (CNN) and performed statistical analysis of the spatio-temporal variations of flash aurora taken by an EMCCD camera (100 Hz sampling, 256 * 256 pixels) at Gakona (Alaska).

The learning data was obtained by dividing the keogram images (2400 * 720 pixels, 1-minute period) along the north-south direction of all-sky EMCCD data into square blocks (30 * 30 pixels, 750-ms period), then the learning data was visually classified to four classes. Four classes are, "pulsating aurora", "flash aurora", "noise", and "no aurora or noise". We classified the test data using the CNN, its accuracy was 91.2%.

The flash aurora data (about 100 events) are collected by CNN and we extracted flash auroral region using Otsu's method, which is a basic method of contour extraction. We performed statistical analysis about luminous duration, luminous point, spatial size, and spatial extent of flash aurora. The averaged luminescence duration was 0.21±0.08 seconds, and did not depend on magnetic longitudes and latitudes in the field-of-view of camera. We confirmed that most events (about 70%) expand earthward with an average spatial extent of 0.027 Re. We think that the earthward extension can be caused by wave propagation effects of whistler mode waves and the nonuniformity of spatial distribution of loss cones in the magnetosphere.
In this presentation, we will report on our automatic detection method and statistical results of spatio-temporal analysis of flash aurora in detail.

Keywords: Convolutional Neural Network, pulsating aurora, flash aurora

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Study on the pulse noise removal technique for Pc1 geomagnetic pulsations on the ground by signal processing

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An electromagnetic ion cyclotron (EMIC) wave, which is a type of plasma waves generated in the magnetosphere, propagates along the geomagnetic field line and we can observe it as the fluctuation in the geomagnetic field on the ground called Pc1 geomagnetic pulsation (0.2 to 5 Hz). We observe Pc1 pulsations at Kapuskasing (Canada). The ground observation is carried out using an induction magnetometer, and the Pc1 pulsations are observed with a high sensitivity and a high time resolution (64 Hz). However, when the observation instrument vibrates due to a strong wind, pulse noise is included in the observed waveforms.
We have been studying an extracting method of Pc1 pulsation by removing the pulse noise included in observed waveform using signal processing technique. Pulse noise shows in a wider frequency range (0.1 to 10 Hz) than the frequency range of Pc1 pulsation and its duration is shorter than the duration of Pc1 pulsation. Pulse noise removal consists of detecting the pulse noise candidate, classifying the pulse noise candidates into pulse noises and others by Neural Network (NN), and interpolating the waveform at the pulse noise domain. In the first step, we set an amplitude threshold for the differential waveform to detect pulse noise candidates. In the second step, as learning data for classification, we use waveform applied a High Pass Filter (HPF) to emphasize pulse noises. In the third step, we use an average energy around the pulse noise in the interpolation. We use random phase, observation phase including the pulse noises, and estimated phase by nonlinear least squares method. For each phase, we evaluated the SNR before and after the pulse noise removal. As a result, the SNR improved with 22dB using the estimated phase, but it requires a huge calculation time.
In this presentation, we will report on the pulse noise removal of Pc1 pulsation using signal processing technique in detail. Conventionally it was necessary to examine and construct the observation environment which suppresses the vibration of the observation equipment as much as possible, we think that our signal processing will be useful for reducing the ground observation costs and a more detailed analysis of Pc1 pulsation.

Keywords: Pc1 geomagnetic pulsation, Noise removal, Signal processing

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Application of magneto-impedance sensor to geomagnetic field measurements

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Magneto-impedance (MI) effect was discovered about 25 years ago and a micro-size magnetic sensor that utilizes this effect becomes commercially available. We made some modifications to the commercially available MI sensors as they can cover the range of the geomagnetic field. For the period of March 30 to April 27, 2018, we conducted experimental observations of geomagnetic field variations with the MI sensors at Mineyama observation site, which is located about 100 km north-west of Kyoto. Data obtained with the MI sensors were compared with those from the fluxgate magnetometer that has been working at the site. Results showed that the MI sensor recorded geomagnetic variations with amplitudes of ~1 nT that were also detected with the fluxgate magnetometer. This suggests that MI sensors are useful for researches in geomagnetism or space physics, although they are much less expensive than fluxgate magnetometers.

We consider developing two different kinds of systems to measure the geomagnetic field using the MI sensor: a system for ground-based observation and a system for a sounding rocket. In presentation, we will display observation data from the MI sensors and the fluxgate magnetometers at Mineyama and other observatories. Future plans of the system onboard sounding rocket will be also presented and discussed.

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Observation of the Ionospheric Currents by the CubeSat at the Low and Middle Latitude

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The ionospheric currents flowing in the dayside ionosphere have been considered as a significant subsequence of Mesosphere-Ionosphere-Magnetosphere coupling. These currents were well detected in the Solar quiet conditions and named Sq currents. In particular, it is well known that the flow pattern of Sq currents shows the north-south hemispheric asymmetry due to the different ionospheric conductivities in the winter and summer hemispheres. This indicates that the asymmetry of the potential must be kept by the energy balance between each hemisphere through the field line.
An InterHemispheric Field Aligned Current (IHFAC) was theoretically predicted by Maeda [1974] and Fukushima [1979, 1991] to interpret the north-south asymmetry in the potential pattern. Several ground magnetic observations and satellite observations suggested an existence of the IHFAC in the noon sector and both the morning and evening terminators. However, the detailed morphology of the IHFAC have not been well understood yet, despite that the direct detection of the IHFAC at Low Earth Orbit (LEO) was reported in the observation by several satellites.
In order to investigate the Sq current system including the IHFAC, the in-situ observation by a CubeSat (2U size satellite emitted from ISS) is proposed in collaboration with 10 national colleges which belong to National Institute of Technology (KOSEN). The fluxgate magnetometer is onboard the CubeSat to observe small perturbations of the magnetic field. After the ejection from the ISS, the CubeSat will gradually glide down to the upper atmosphere due to the strong atmospheric drag and finally burn up in it. The duration of possible observation is estimated for more than 50 days.
The CubeSat can be characterized by the short duration of development (less than 3 years) and low cost (less than 100,000USD). We are considering an actual utilization of this extremely low-cost CubeSat to more realistic science mission. This concept enables us to conduct the multi-satellite in-situ observation in fairly low budget compared to conventional satellite missions.

Keywords: Ionospheric Current, Interhemispheric Field Aligned Current, CubeSat

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Basic study on miniaturization of electric field instrument for plasma wave observations by ASIC technology

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We have been measuring electric fields of the plasma waves (a few Hz to several hundred Hz) to understand the magnetospheric dynamics. The spatial resolutions of electric field measurements are not enough because we cannot launch a lot of satellites due to the large size and mass of satellites. Demands of micro satellites like a 1U (10 cubic centimeters) cube satellites are increasing. We need to miniaturize measurement instruments for probing the plasma waves.

This study deals with an electric field instrument in plasma wave observations. We use the electric field instrument for capturing the electric fields detected by wire probe antennas. In this study, the purpose is to miniaturize the electric field instrument with a high radiation tolerance (300 krad) using Application Specific Integrated Circuit (ASIC) technology.

We designed a based amplifier for a new electric field instrument. In the new based amplifier, the equivalent input noise is 50 nV/sqrt(Hz) at 1 kHz, which is 3.9 dB-larger than that of conventional based amplifier (OP-41). The noise performance of new based amplifier is acceptable for capturing the plasma waves. To confirm the radiation tolerance of new based amplifier, we did the radiation tests up to 300 krad using the gamma ray. From the radiation test results, the gain was no change before and after the radiation tests. The output noise was degraded with 5.05 dB at 100 Hz by total ionizing dose effects. However, the based amplifier was not breakdown by the gamma ray. The electric field instrument consisted of new based amplifier could operate with a high radiation tolerance.

We conducted the transient analysis for the new electric field instrument by a circuit simulator (Tanner EDA). In the simulation, rectangular waves of 1 Vpp with 10 Hz input to the new electric field instrument via a sheath impedance (10 MOhms and 100 pF). From the simulation results, the output waveforms of new electric field instrument showed similar output waveforms in comparison with the conventional electric field instrument. The power consumption of new electric field instrument can decrease with approximately 67% than that of the conventional electric field instrument. From the simulation results, we confirmed the basic operations as the electric field instrument for detecting the plasma waves. In the future work, we will need to improve the temperature operating range because the new electric field instrument cannot operate at minus 60 Celsius degrees from the temperature simulation results.

In this presentation, we will present the basic study on electric field instrument for plasma wave observation by ASIC technology in detail.

Keywords: ASIC, Electric field instrument, Plasma wave observation

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Evaluation of radiation tolerance of electronics parts used for the ultra-small mission

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In the space environment, spacecraft is exposed to radiation and degrades the data. For example, the increase of dark current, and change in current consumption.

Recently, the university-made ultra-small spacecraft mission become popular. The mission in this class can reduce the cost and time by using commercial products. However, these commercial products are thought to have no radiation tolerance. Then, it is necessary to be tested with the radiation total dose which is calculated using the Monte Carlo simulation.

We are developing the extreme ultraviolet imager PHOENIX onboard the ultra-small satellite EQUULEUS which will be launched in 2020. Helium ions in the Earth’ s plasmasphere emit extreme ultraviolet light (wavelength of 30.4 nm) through the solar resonance scattering. PHOENIX observes them from the moon (Earth-Moon L2 point).

The radiation tolerance has been evaluated with a gamma irradiation facility with cesium 137. In this presentation, we show the gain characteristics and change of electric noise with respect to radiation of semiconductor elements used in PHOENIX instrument.

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A method to quantitatively evaluate Non-evaporable-getter pump for use in space science mission

*Seiya Nishimura[1], Ichiro Yoshikawa[1], Kazuo Yoshioka[1], Shogo Arao[1], Zhang Tianxu[1]

1. The university of tokyo

Observation instruments are known to deteriorate under atmospheric condition. Deterioration are mainly caused by reaction with water vapor and oxygen. To prevent this, observation instruments must be maintained under vacuum. The problem is that the conventional vacuum pump are too heavy to carry to the launching site. The need of continuous power supply makes the transport more difficult. Also the vacuum pump must be removed before the launch. These problems are not only making it difficult to maintain observation instruments under vacuum but also causing extra costs. Non-evaporable-getter (NEG) pumps are able to solve these problems. NEG pumps are light weight, compact, oil free, vibration free, and able to operate without energy supply after activation. Considering the utilization of NEG pump for space science missions, we need to quantitatively evaluate the NEG pump to optimize its size, shape, material, and mounting position for each mission. In this study, a method to measure pumping speed of NEG pump for carbon monoxide (as substitute to water vapor and oxygen) was established by using the orifice method. By using this method, it will be able to develop a NEG pump which best applies the case for each mission.

Keywords: Non-evaporable-getter pump, vacuum pump

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Interpretation on slight asymmetry of analyzer characteristics of MIA onboard the Mio by means of a model calculation of 3-D potential distribution

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1. Tokai University, 2. ISAS, 3. Osaka University

MIA (Mercury Ion Analyzer) on board Mio employs a top-hat electrostatic analyzer, which has axisymmetric toroidal electrodes and is designed to have no dependence in its characteristics on azimuthal direction of incident ions. However, our ground calibration experiments have revealed that it has a slight dependence. We have tried to explain the dependence by means of three dimensional model calculations. We assumes that all parts of electrode are manufactured precisely. Our results shows that a slight relative rotation (or tilt) of electrodes can lead to a slight dependence on incident azimuthal direction similar to that obtained from the ground experiments.

Keywords: Mio, tophat electrostatic analyzer , MIA

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Construction of impact testing machine for small satellites and evaluation of mechanical resistance of MCPs by the impact test

*Junya Fukuba[1]

1. Graduate school of Tokyo

Small satellites have been developed in recent years. Environmental tests at the development stage play an important role in improving reliability of small satellites. These include a vibration test, an impact test, and a thermal vacuum test. Especially, the impact test is one of the most difficult tests and a reliable method has not yet been established. Against such a background, we constructed an impact testing machine for small satellites. Required performance of the impact testing machine is a controllability and a reproducibility. The controllability means the performance of applying a targeted impact level accurately. This is important to avoid applying excessive impacts on a test target. The reproducibility means the performance of applying same impact level repeatedly and this is also important because if it is possible to apply an unintended impact under the same condition, it degrades the test accuracy. Our impact testing machine is designed to be able to easily adjust the impact level and have high reproducibility. Furthermore, we tested for mechanical resistance of the MCP (micro-channel plate) which is used for optical observation instruments. In this test, we used an impact level assuming the EQUULEUS mission which will be launched by NASA’ s rocket in 2020. In my presentation, I will introduce the details of our impact testing machine and the impact test results of MCP.

Keywords: impact test

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Innovative design of double-shell type energy analyzer for simultaneous electron and ion measurements in space

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It is well known that the terrestrial and planetary magnetospheres and the interplanetary space are filled with charged particles such as electrons and ions, which are so-called the space plasma, and in-situ observations of the space plasmas have been conducted by using satellites carrying particle instruments, such as the top-hat type electrostatic energy analyzer. Essentially, obtaining three-dimensional velocity distributions of the space plasmas or energy-pitch angle distributions help us understand the dynamics of the space plasmas. Because the top-hat type analyzer is cylindrically symmetric and has a 2π-radian planar field of view, it can independently measure the wide angular and energy distributions of incident particles. Also, three-dimensional velocity or energy-pitch angle distributions can be obtained by utilizing the satellite spin motion.
The top-hat type electrostatic energy analyzers can measure the ions when a negative potential is applied to the inner electrode and the electrons by a positive potential with the outer electrode grounded. Therefore, in the prevailing design of the top-hat type analyzer, the sensor heads separate for the ion and electron observations, respectively. Because of the recent miniaturization of the satellites, the weight and space of the instruments mounted on the small and micro satellites are getting severely restricted. However, if two sensors for electron and ion observations are combined into one sensor head, it is possible to save both weight and space on the small and micro satellites. Therefore, we have been developing double-shell type energy analyzer which can simultaneously measure the ions and the electrons with one sensor head.
We designed the shapes of the collimator and the double-layered dome-shaped electrodes so that the electrons and the ions with appropriate energies pass through the inner gap and the outer gap by applying a negative potential to the central electrode with the inner and outer electrodes grounded, respectively. We made the numerical simulations using SIMION which is a charged particle simulator program and investigated the performance and characteristics as the electrostatic analyzer. Consequently, we confirmed that the electrons and the ions can be analyzed with one sensor head by only applying negative high voltage to the electrodes. So far, we consider the detection unit using Time-Of-Flight velocity spectrometer for the discrimination of the ion species as the part where the ions are detected, and an assembly of micro channel plates is expected for the electron detection. The design of TOF-type mass analysis unit as ion mass analysis unit is one of subjects for future work.

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Microsatellite Development and Education of Space Science and Technology at Kanazawa University

*Tomohiko Imachi[1], Satoshi Yagitani[1], Daisuke Yonetoku[1], Yoshiya Kasahara[1], Tatsuya Sawano[1], Makoto Arimoto[1], Yoshitaka Goto[1], Mitsunori Ozaki[1], Ryuichi Fujimoto[1]

1. Kanazawa University

At Kanazawa University, researchers from engineering and science are cooperating to promote the "Kanazawa University Satellite Project (Kanazawa-SAT3: Study and Training in Space Science and Technology for Kanazawa Cube-Satellites)". In this project, a microsatellite is being developed by staff and students of Kanazawa University. It is a scientific satellite which will contribute to the elucidation of the mechanism of gravitational wave generation by identifying the source of gravitational wave by detecting the arrival direction of gamma rays and X rays radiated at the same time when a gravitational waves are generated by collision of astronomical objects The satellite will be inserted into a solar synchronous orbit at about 660 km altitude. It is a microsatellite with a total weight of 50 kg or less, and its size is cubic with a side of 50 cm, and it is designed to be a piggyback on an HII-A rocket.

Also related to this project, a space science and engineering course has been newly established in the Graduate School of Natural Sciences in April 2018. This course is based on the 'satellite development by students', and students are actually involved in the design, fabrication, ground tests, and operation of scientific satellites, aiming to train personnel who are familiar with space science and space engineering, with satellite-development skills.

Ground tests with the thermal and structural model of Kanazawa-SAT3 have been completed , and the unit tests for almost all components are being conducted. Currently, we are completing the design of the flight model. In the presentation, we will report the details of Kanazawa-SAT3 and its development status.

Keywords: Microsatellite, Gravitational wave, Kanazawa SAT3

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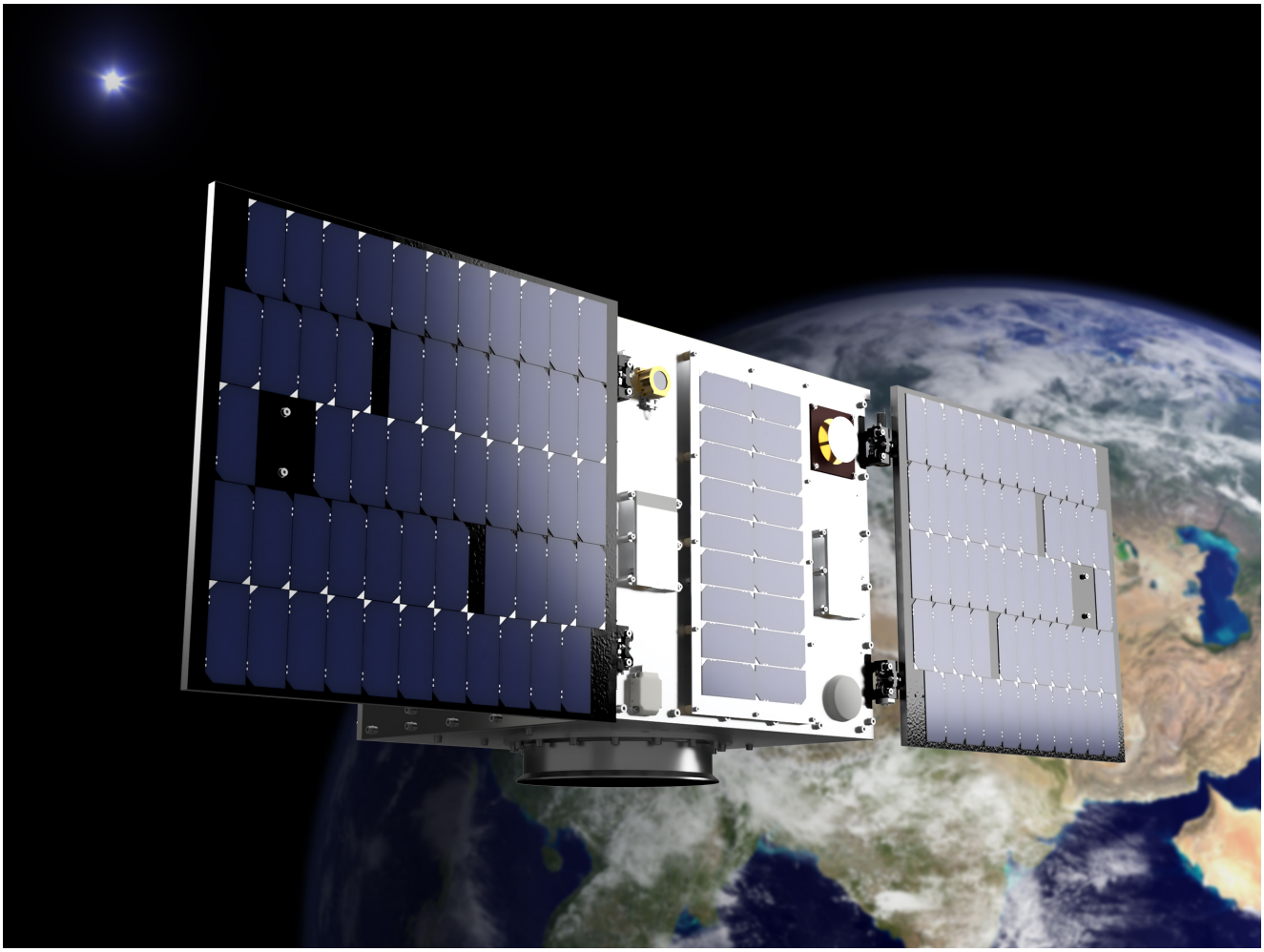

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Attitude Control System for Kanazawa-SAT3 Microsatellite

Takuya Nakajima[1], Yuuki Yasuda[1], Hirofumi Segawa[1], *Tomohiko Imachi[1], Satoshi Yagitani[1], Yoshiya Kasahara[1], Daisuke Yonetoku[1], Tatsuya Sawano[1], Makoto rimoto[1]

1. Kanazawa University

Kanazawa University has been developing a microsatellite. This satellite is equipped with a device to observe celestial bodies emitting gravitational waves with X rays, and aims to elucidate the mechanism of black hole formation by estimating the time of arrival and direction of arrival of gravitational waves.
In this research, the attitude control system is being developed using GAS (Geomagnetic Aspect Sensor) and MTQ (Magnetic Torque). We have constructed the environment for the unit test of RW (Reaction Wheel) also used for attitude control of the satellite.

MTQ is a device that controls the attitude of the satellite by generating a magnetic torque against the geomagnetic field by applying a voltage (an electric current) to a magnetic coil. GAS is a device for detecting the direction of the geomagnetic vector. OBC (On Board Computer) which controls all devices mounted on the satellite receives the geomagnetic field data detected by GAS, and transmits commands to control MTQ. GAS and MTQ cannot be connected to OBC directly, because OBC has just a digital interface, but the output of GAS and the input to MTQ are analog voltages. Therefore, we have developed a control device for on-board equipment using a microcontroller. For the GAS, the voltages are A/D-converted by the microcontroller and transmitted to the OBC. For the MTQ, OBC transmits control commands to the microcontroller, which generates a PWM (Pulse Width Modulation) signal according to the received command that determines the effective voltage to be given to the MTQ. For the system development and operation tests, a PC is used instead of OBC and we carried out experiments of control equipment. For the GAS, we have confirmed the linearity between the analog magnetic field and the corresponding digital values transmitted to the PC. For the MTQ, we have confirmed that the voltage to be given to MTQ were precisely controlled by the duty ratio of the PWM signal output from the microcontroller.

RW is a device to generate a control torque around the rotation axis by accelerating a rotor by a motor and is controlled by transmitting a command from the OBC via an RS-422 serial communication line. The unit test has been carried out by using a PC as a substitute of OBC, but the cable had a influence on the rotation operation of RW. Therefore, we have constructed a system for wirelessly connecting the RW with the PC via a wireless RS-422 communication. Specifically, commands from the PC are wirelessly transmitted to an Arduino microprocessor by a low-power radio module XBee, and the RW is controlled via an RS-422 transceiver. With this system, we demonstrated the basic functions for command and data between the PC and the Arduino via the wireless RS-422 transceiver.

We plan to construct a system that applies appropriate PWM signals to MTQ according to the value detected by GAS. We will also evaluate RW performance by the unit test using the wireless RS-422 communication system.

Keywords: Microsatellite, ACS, Kanazawa SAT3

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Communications System and Antennas for Kanazawa-SAT3 Microsatellite

Teruya Minamoto[1], Koyo Ina[1], Kohei Kawagoshi[1], *Tomohiko Imachi[1], Satoshi Yagitani[1], Yoshitaka Goto[1], Daisuke Yonetoku[1], Yoshiya Kasahara[1], Tatsuya Sawano[1], Makoto Arimoto[1]

1. Kanazawa University

Kanazawa University is developing the first Kanazawa University's microsatellite, named as Kanazawa-SAT3. Kanazawa-SAT3 is planned to be launched within FY2019, and its observation mission is to identify the source of gravitational waves by detecting the occurrence time and arrival direction of the X-rays and gamma rays observed simultaneously with gravity waves from distant astronomical objects.

In this research, we are developing a communications system for Kanazwa-SAT3. Kanazawa-SAT3 has three different communication systems using S band, UHF band and Iridium, and the link design of each of them has generally been completed. We summarize each communication system in detail as the following.

The S-band communication system, will use 2-GHz frequency band. Kanazawa-SAT3 is equipped with two types of antennas: S-band patch antennas and S-beacon antennas. S-band system is a main communication system between the satellite and a ground station, and plays a role of high speed data communication and beacon transmission. On the satellite side, two S-band patch antennas designed for both transmission and reception are mounted on the front and rear panels of the satellite. Two S-beacon antennas for transmission are also mounted on the front and rear panels of the satellite. On the ground side, we will send and receive by the signals using a 2.4-m parabolic dish installed at Kanazawa University.

The UHF communication system will use 400-MHz frequency bands. This system transmits commands from the ground to the satellite and telemetry information from the satellite to the ground. On the satellite side, four inverted-F type antennas we developed are mounted (two for receiving and two for transmitting) on the front and rear panels of the satellite. On the ground side, we will send and receive data by using a Yagi antenna with 14 crossed elements installed at Kanazawa University. We have also constructed an automatic satellite tracking system using the Yagi antenna.

A communication system using the Iridium satellite network uses a frequency band around 1.6 GHz. In this system, communications are performed via Iridium satellite, so that the communication can be established even when our ground station is not visible from the satellite. The data is exchanged between the satellite and the ground by using e-mail. This system can transmit and receive data in almost real time so emergency command and data transmission will be available. On the satellite side, two antennas for both transmission and reception are mounted on the front and rear panels of the satellite. A system has been constructed that exchanges data between a laptop computer simulating an onboard computer (OBC) mounted on a satellite and an iridium satellite.

From now on, for the communication systems using the S band and the UHF band, it is necessary to develop the communication software. For In addition, we need to improve the automatic satellite tracking system of Kanazawa-SAT3. For the communication system using Iridium satellite, it is necessary to implement a system on the OBC and conduct a communication experiment.

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Keywords: Microsatellite, Communications System, Kanazawa SAT3

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Development of micrometeoroid impact sensor within a multi-layered insulation (CLOTH) onboard 6U deep-space explorer EQUULEUS

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In recent years, the use of CubeSat for deep-space exploration is remarkably expanding. Equilibrium Lunar-Earth point 6U Spacecraft (EQUULEUS) project led by the University of Tokyo and JAXA is one of 13 sub payloads which will be launched by the NASA’ s new rocket, Space Launch System (SLS) in 2019 or later. In addition to the engineering mission of orbital maneuvering, EQUULEUS will perform 3 scientific missions consisted of geo-corona, lunar impact flash, and micrometeoroid observations on the way to the Earth-Lunar libration point 2. Our Cis-Lunar Object detector within THermal Insulation (CLOTH) is a piezoelectric film sensor integrated with the EQUULEUS’ s multi-layer insulation (MLI). CLOTH can detect micrometeoroid which impacts and penetrates the outermost layer of EQUULEUS's MLI. The space flight demonstration of CLOTH will expand the possibility of deep-space exploration by CubeSat. In this presentation, we introduce the concept of CLOTH, i.e. micrometeoroid detector integrated with a spacecraft bus component, and the detection performance estimated by hypervelocity microparticle impact test on the ground.

Keywords: Piezoelectric film, PVDF, Thermal insulation, CubeSat, Micrometeoroid, Hypervelocity impact

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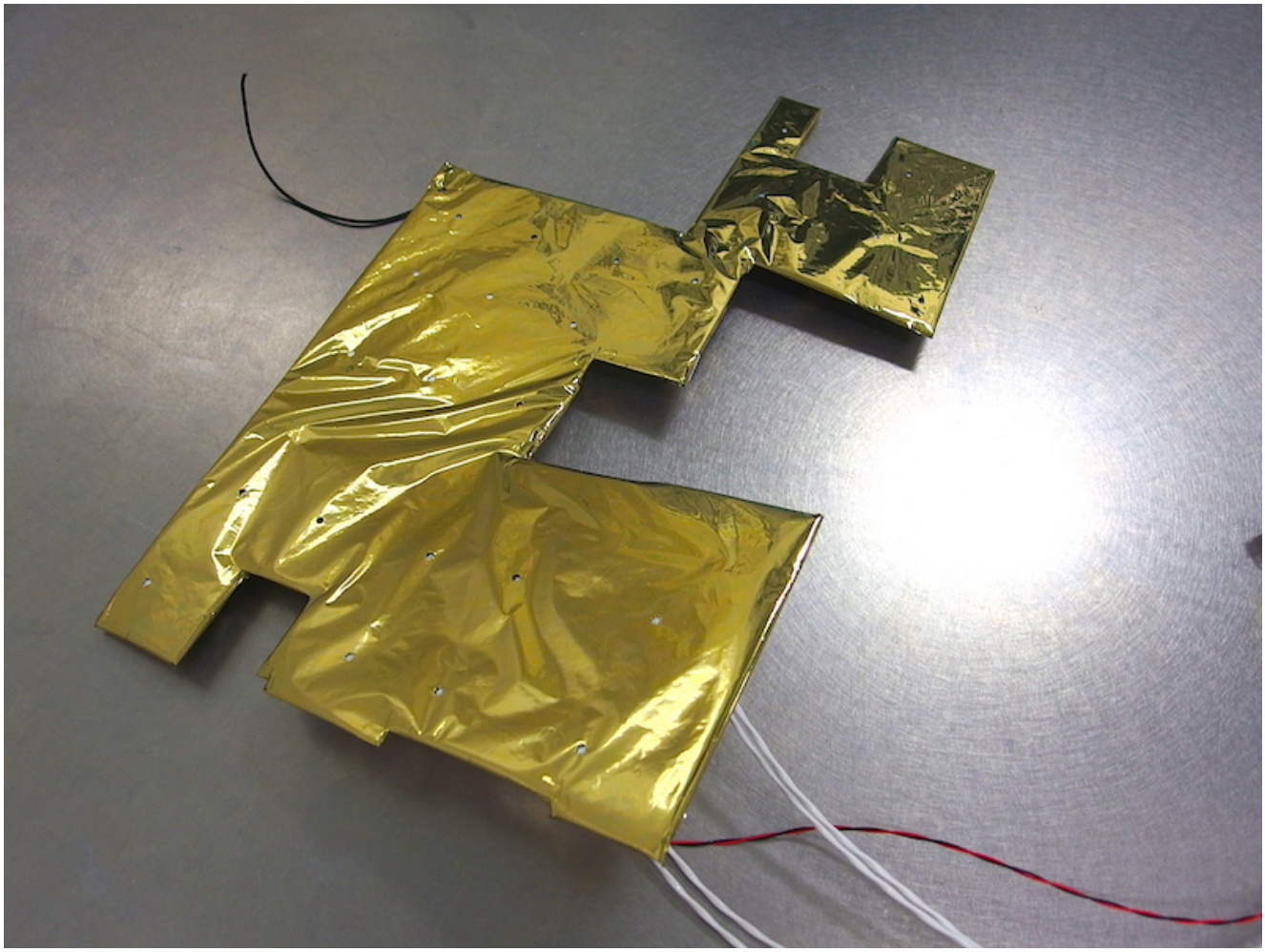

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Breadboard model of asteroid tracking system for DESTINY^{+} mission

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DESTINY^{+} (Demonstration and Experiment of Space Technology for Interplanetary voYage, Phaethon fLyby and dUst Science) is a mission proposed for JAXA/ISAS Epsilon class small program, currently in the pre-project phase (Phase-A) with a launch targeted for 2023. The mission plans to conduct high-resolution imaging during close flyby of asteroid (3200) Phaethon, which is considered as a parent body of Geminid meteor shower. Two cameras are planned to be onboard DESTINY^{+}, the Telescopic Camera for Phaethon (TCAP) and the Multiband Camera for Phaethon (MCAP). While MCAP is designed for low spatial resolution imaging, TCAP is planned to perform high-resolution imaging, especially from ~40 seconds before to ~9 seconds after the closest approach with an imaging rate of more than 1 frame per second and the surface of Phaethon will be imaged with a spatial resolution up to 3.5 m/px at closest approach. Both cameras will be mounted and installed on the wall of spacecraft bus, thus orientations of the cameras are mainly controlled by the attitude of spacecraft. However, since the relative flyby speed and closest distance to Phaethon are expected to be 30 to 40 km/s and about 500 km, it is significantly difficult to track the asteroid only by the rotation of the spacecraft itself. Therefore, an asteroid tracking system is required for TCAP to obtain unblurred high-resolution images. The tracking system is also required to operate autonomously during the high-speed flyby. We have conducted conceptual studies of the tracking mirror as well as control algorithms to properly navigate the mirror based on feedforward or feedback loop. To realize the designed concept, we have developed a simple breadboard model focusing on the rotating mechanism which is the most important part of tracking mirror. The breadboard model consists of a rotating mirror, a 2-phase stepping motor and its driver, a motor reducer, and a FPGA board to control the driver. Required performances for the breadboard model of tracking system are (1) the rotating mirror should be able to orient a desired direction with an enough accuracy, (2) the mirror should be able to rotate smoothly with an enough accuracy during the exposure of TCAP. We will report the current development status of breadboard model of asteroid tracking system for TCAP and show its initial results of the performance test.

Keywords: DESTINY+, camera, flyby, tracking system

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Development of telescopic camera (TENGOO) performance evaluation device in MMX

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1. Rikkyo University, 2. Japan Aerospace Exploration Agency

Mars has two satellites, Phobos and Deimos, and there are currently two hypotheses for the origin of these satellites. The first of these hypotheses is that the moons are captured primitive asteroids, and the second is that they formed because of a giant impact event on Mars. The Japan Aerospace Exploration Agency (JAXA) is planning the Martian Moon eXploration (MMX) mission, which is a sample-return mission for Phobos, to determine which hypothesis is correct and reveal the origin of these two satellites.

The TElescopic Nadir imager for GeOmOrphology (TENGOO), which will be installed in MMX, has the purpose of measuring the geographical features of Phobos to locate a suitable landing site less influenced by space weathering. The design of TENGOO was optimized for achieving this goal. In the optical design, the instantaneous Field of View (iFoV) is 5.8 μrad/pix and the Modulation Transfer Function (MTF) is 0.3 at the Nyquist frequency.The design performance of the manufactured TENGOO needs to be confirmed. We evaluate the performance of TENGOO by measuring the Point Spread Function (PSF). Therefore, a low divergence collimated light is needed for a ground experiment to obtain the PSF with sufficient accuracy. We succeeded at making a collimated light source with divergence less than 11.6 μrad.

The Full Width of Half Maximum (FWHM) of PSF obtained with this collimated light is approximately 2x2 pixels in TENGOO. Therefore, the sampling interval becomes wider than FWHM of PSF, and the error of PSF estimation due to Gaussian fitting increases. To solve this problem, we measured the Line Spread Function (LSF) with diagonal lines and complemented the measuring points by obtaining multiple PSFs.

Keywords: Mars, MMX, camera

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Observation Plans in the Cruising-Phase of the Solar Power Sail: OKEANOS

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1. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 2. Kwansei Gakuin University, 3. Tohoku University, 4. Chiba Institute of Technology, 5. Kanazawa University, 6. RIKEN

The solar power sail mission: OKEANOS (Oversize Kite-craft for Exploration and AstroNautics in the Outer Solar system) is a Japanese candidate deep-space probe that will be powered by hybrid propulsion of solar photon acceleration and ion engines. The main scientific objectives are studies of Trojan asteroids in the Jovian L4 or L5 regions. The long distance and period from the launch to the swing-by at Jupiter will give us a good opportunity to explore the solar system between the Earth and the Jupiter to elucidate the solar system disc structure. We define the cruising-phase sciences of the OKEANOS mission as the scientific theme that will be explored or observed from the launch to the swing-by at Jupiter. Candidates of instruments for the cruising phase are: the EXo-Zodiacal Infrared Telescope (EXZIT), the Arrayed Large-area Dust detectors in INterplanetary space (ALADDIN)-2, the MaGnetic Field experiment (MGF), and the GAmma-ray burst Polarimeter (GAP)-2. In this paper, we report scientific purpose and observation plans of them.

Zodiacal light observed at visible and near-infrared wavelengths is thought to be sunlight scattered by interplanetary dust. The two-dimensional distribution of zodiacal light reflects the three-dimensional structure of interplanetary dust. However, it is still controversial that how the ratio of asteroid-origin to comet-origin changes by the heliocentric distance. Therefore, the comparison of the radial distribution of zodiacal light and the in-situ dust observation will help clarify the distribution and components of solid particles in our solar system. These results are expected to provide precise distribution of the interplanetary dust in our solar-system discs.
The temperature of the solar wind, which depends on the heliocentric distance, has been observed to be greater than that predicted by the adiabatic model. Therefore, the existence of heating processes, such as plasma turbulence or magnetic reconnection, could be predicted. The observation of the magnetic field by the devices separated in the scale of the membrane of the Solar Power Sail provides the resolution of the plasma turbulence on the electron scale. Thus, the intermittent observation of the magnetic field between the Earth and Jupiter would determine the heating mechanism of the solar wind. The synergy of the magnetic field and dust observation may show the interaction between interplanetary dust and solar wind. By analyzing the environments on the dust surface, the chemical evolutions of molecules caused by solar wind and cosmic radiation can be investigated. We are investigating the possibilities to detect gamma-rays and particles from the solar-system shocks.

Keywords: OKEANOS, zodiacal light, dust, plasma, gamma-ray

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[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 201B 2F

[P-CG23] Origin and evolution of materials in space

convener:Hitoshi Miura(Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University), Hideko Nomura(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Takafumi Ootsubo(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Aki Takigawa(Division of Earth and Planetary Science, Kyoto University), Chairperson:Ryo Tazaki, Aoi Takahashi

Recent progresses of astronomical observations, laboratory experiments, solar-system exploration, and theoretical work have enabled us to attempt to understand the origin and evolution of materials (dust and gas) in space in the context of material science. It is thus important to link further planetary material science and astronomy for comprehensive understanding of dust and gas in space and their role in evolution of galaxies, stars, and planetary systems. In this session, based on latest results on astronomical observations, experiments, and theoretical studies on materials in space, we discuss next steps in science for materials in space.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[PCG23-01] Origin of cosmic dust: Galaxy-scale perspective

★Invited Papers

*Akio Inoue[1,2] (1.Osaka Sangyo University, 2.Waseda University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[PCG23-02] SPICA and future infrared observations of cosmic matters

★Invited Papers

*Issei Yamamura[1] (1.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[PCG23-03] Engineering first light of a new mid-infrared instrument MIMIZUKU

*Takafumi Kamizuka[1], Takashi Miyata[1], Shigeyuki Sako[1], Ryou Ohsawa[1], Masahito S. Uchiyama[1], Tomohiro Mori[1], Yutaka Yoshida[1] (1.Institute of Astronomy, School of Science, the University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[PCG23-04] Properties and space exposure of Quenched Nitrogen-included Carbonaceous Composite (QNCC)

*Izumi Endo[1], Itsuki Sakon[1], Takashi Onaka[1], Yoko Kebukawa[2], Kensei Kobayashi[2], MITA Hajime[4], Hajime Yano[3] (1.University of Tokyo, 2.Yokohama National University, 3.ISAS/JAXA, 4.Fukuoka Institute of Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[PCG23-05] Shape dependence of dust absorption opacity in the Rayleigh domain

*Ryo Tazaki[1], Hidekazu Tanaka[1] (1.Astronomical Institute, Tohoku University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[PCG23-06] Modeling of the H_2 ortho-para spin conversion on grain surfaces in star- and planet-forming regions

*Kenji Furuya[1], W. M. C. Sameera[2], Tetsuya Hama[2], Naoki Watanabe[2], Yuri Aikawa[3] (1.Center for Computer Sciences, University of Tsukuba, 2.Institute of Low Temperature Science, Hokkaido University,, 3.The University of Tokyo)

Origin of cosmic dust: Galaxy-scale perspective

*Akio Inoue[1,2]

1. Osaka Sangyo University, 2. Waseda University

Galaxies are the fundamental component of the Universe. In the Milky Way Galaxy and other galaxies in the present (i.e. nearby) Universe, the mass ratio of dust and stars integrated over a galaxy-scale is about 0.1%. On the other hand, in the Universe several hundreds million years after the Big Bang, some galaxies have been detected in dust with ALMA but others haven't. The dust-to-stellar mass ratio integrated in a galaxy-scale is distributed over more than an order of magnitude. In this talk, I will discuss the reason of this diversity in dust mass in the early Universe and the origin of dust in a galaxy-wide scale.

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SPICA and future infrared observations of cosmic matters

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SPICA (Space Infrared Telescope for Cosmology and Astrophysics) is an ESA-JAXA joint mission for infrared astrophysics. The main goal of the mission is to make significant contribution to answer the essential questions; how the universe has evolved to the current state of being rich in metals and cosmic dust, and how our solar system involving life has formed and developed.
SPICA is equipped with a 2.5 m telescope operated at cryogenic temperature (8 K). Three scientific instruments on board are SPICA Mid-infrared Instrument (SMI), SPICA Far-infrared Instrument (SAFARI) and Magnetic field explorer with Bolometric Polarimeter (B-BOP). SMI covers 18-36 μm with spectral resolutions R~100 or 2000, and 12-18 μm with R~28000 and it is also capable of imaging at 34 μm. SAFARI observes 34-230 μm in four wavelength bands at spectral resolution of R~300 or 2000-11000. B-BOP carries out imaging polarimetry at 100, 200, and 350 μm.
Thanks to the cryogenic telescope and the cutting-edge sensor technique, SPICA will realize sensitivity two orders of magnitude better than that in the previous missions such as Herschel. Significant fraction of the observing time will be open to the committee as proposal-based observations. Various celestial objects can be targets for observation with SPICA. For instance, high-quality spectroscopic data of trans-Neptunian objects and planet-forming circumstellar disks may clarify detailed formation process of our solar system. Observation of circumstellar dust of mass-losing stars at various environments will inform us how the cosmic dust are provided into our universe.
SPICA was selected as one of three candidates for ESA Cosmic Vision M5 mission from 25 proposals in May 2018, and it is currently under conceptual design. JAXA is a major partner, and will provide cryogenic payload module (PLM) and SMI. SAFARI and B-BOP are provided by the European consortia. The final selection of M5 will be in mid 2021, and the launch is expected to be late 2020's.

Keywords: Infrared, Space Mission, Dust

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Engineering first light of a new mid-infrared instrument MIMIZUKU

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The University of Tokyo is currently constructing an observatory, the University of Tokyo Atacama Observatory (TAO), in the Atacama Desert in Chile. The site is located at the summit of Cerro Chajnantor, whose altitude is 5640 m. The high altitude and the dry climate decrease the water vapor in the atmosphere (Precipitable Water Vapor <0.5 mm) and improve the atmospheric transmittance in the infrared region. Therefore, the site is one of the most ideal places for infrared observations on the ground. By placing a large-aperture telescope (6.5 m in diameter) at the site, we make the TAO a cutting-edge facility for infrared observational astronomy. The Mid-Infrared Multi-field Imager for gaZing at the UnKnown Universe (MIMIZUKU) is the first-generation mid-infrared instrument for the TAO. The main features of MIMIZUKU are: 1) wide wavelength coverage from 2 to 38 microns, 2) high-spatial resolution, and 3) accurate calibration of the atmospheric absorption. The wide wavelength coverage is achieved by installing three optical channels, NIR, MIR-S, and MIR-L, covering 2.0-5.3, 6.8-26, and 24-38 microns, respectively. Each channel can perform imaging and low-resolution spectroscopic observations. The high spatial resolution is achieved by the large-aperture telescope, which determines diffraction-limited spatial resolution. The calibration accuracy of the atmospheric absorption is improved by installing a special optical device called Field Stacker. The Field Stacker has three movable mirrors and is placed on the telescope focal plane. The mirrors pick off the light from two sky regions and combines them into one field. Then, we can observe two different sky regions simultaneously. By using this function, we can perform simultaneous observations of scientific target and reference object. Simultaneous observations allow us to compensate the time variation of the atmospheric absorption and improve accuracy of its calibration. If this function successfully works, we can realize stable and accurate observations even in wavelength regions with low atmospheric transmittance, like ozone absorption region around 9.6 microns and long-wavelength mid-infrared regions in >20 microns.

Ahead of the completion of the TAO, planned around late-2020, engineering observations of MIMIZUKU were carried out at the Subaru telescope in July and December, 2018. In these observations, the functions of the MIR-S channel and the Field Stacker device were tested. As for the imaging functions, the spatial resolutions in the N- and Q-bands were confirmed to be 0.32 and 0.59 arcsec, respectively. It means that MIMIZUKU can achieve diffraction-limited images in the mid-infrared regions. As for the spectroscopic functions, spectral resolutions for the N- and Q-band modes were measured to be 180 and 100, respectively. These are consistent with the designed values. In addition, the effectiveness of the Field Stacker on the calibration of the atmospheric absorption were also confirmed. It was found that we can reduce the photometric uncertainty to a few percent even under the condition where the photometric count varies with >10 % (p-v) due to the atmospheric variation. As for the spectroscopy, Q-band spectroscopic observations, which have been difficult in ground-based observations, were realized. We found that the atmospheric absorption can be calibrated with the Field Stacker and that we can get spectra in 17-24.5 microns with fluctuations less than 5%.

These capabilities enable us to perform wide-wavelength spectroscopic monitoring observations. Such observations are useful to investigate time variation of temperature and amount of dust produced by dust-forming events around evolved stars like red giants and supernovae. In this presentation, we will

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report the results of the engineering observations and future prospects of the observational studies on dust formation process using MIMIZUKU.

Keywords: Ground mid-infrared observations, Monitoring observations, Dust formation, The University of Tokyo Atacama Observatory (TAO), MIMIZUKU

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Properties and space exposure of Quenched Nitrogen-included Carbonaceous Composite (QNCC)

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Organics are abundant in the present universe. However, we have limited knowledge on their origin and how they have contributed to life in solar system. The Unidentified Infrared (UIR) bands are ubiquitously seen in the various astronomical environments and should be important signals to understand how the primitive form of organics has emerged in the universe because the carriers of the bands are generally believed to be organic species. We have, for the first time, succeeded in synthesizing laboratory organics called Quenched Nitrogen-included Carbonaceous Composite (QNCC) whose infrared properties successfully reproduce the characteristics of the UIR bands observed around classical novae. We have found that N/C ratio (atom) of QNCC is 3-5% based on the measurement with Elemental Analyzer/Isotope Ratio Mass Spectrometer (EA/IRMS). X-ray Absorption Near Edge Structure (XANES) analysis of QNCC have indicated that amine (C-N) structures are contained in the QNCC. We have concluded that amine structures contribute to the broad feature around 8μm which characterize the UIR bands observed around classical novae. The broad band around at 8μm seen in infrared absorption spectra of QNCC is also seen in those of insoluble organic matter (IOM) in carbonaceous chondrites. N/C ratio of QNCC is almost consistent with that of IOM (2-5%). Therefore, QNCC is an important material to investigate the origin of primitive organics in solar system.
Based on above results we have launched a new space exposure experiment of QNCC using ExHAM (Exposed Experiment Handrail Attachment Mechanism) on the International Space Station (ISS) / Japanese Experiment Module ‘Kibo’. This space exposure experiment aims to verify the hypothesis that organics which originates in evolved stars have delivered and contributed to primitive organics in solar system by investigating the changing in properties of QNCC exposed in solar neighborhood space environment and comparing with those of organic matter contained in meteorites. In this presentation, we will report the nature of QNCC which is the strong candidate of the carriers of the UIR bands observed around classical novae and the latest progress of space exposure experiment of QNCC.

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Shape dependence of dust absorption opacity in the Rayleigh domain

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In various astrophysical environments, dust absorption opacity must be assumed to estimate dust mass by observations. Cosmic dust particles often have radii smaller than FIR or more longer wavelengths, and hence, they are typically in the Rayleigh domain at these observing wavelengths. It is known that absorption opacity in the Rayleigh domain sensitively depends on the shape of dust particles. In this study, we study how dust coagulation alters absorption opacity in the Rayleigh domain by using the T-Matrix Method. We find that higher-order terms of harmonic expansion of the electromagnetic field must be taken into account to reproduce strong field appearing around contact points between monomer particles. As a result, we show that coagulation can enhance dust absorption opacity by a factor of about 2 for silicate and about 5 for carbonaceous particles. We discuss appropriate approximate methods to mimic the shape effect of dust absorption opacity.

Keywords: Non-spherical dust particles, Absorption opacity, T-Matrix Method

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Modeling of the H_2 ortho-para spin conversion on grain surfaces in star- and planet-forming regions

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Hydrogen is the most abundant element in the universe. In star- and planet-forming regions, hydrogen is primary present in H_2, which has two nuclear spin configurations, ortho and para. As the internal energy difference between ortho-H_2 and para-H_2 (170 K) is much higher than the typical temperature of star-forming regions (around 10 K), the H_2 ortho-to-para ratio (OPR) can affect the chemical evolution, including deuterium fractionation, significantly.

H_2 molecules form on grain surfaces with the statistical OPR of three. The ortho-para spin conversion proceeds through proton exchange reactions with H^+ and/or with H_3^+ in the gas phase. Laboratory experiments have found that the H_2 spin conversion can also occur on bare grains and on amorphous water ice in laboratory timescales (around a few hours). Given this very short timescale, it has been thought that the spin conversion on surfaces affects the H_2 OPR evolution in star- and planet-forming regions. However, its efficiency in the astronomical conditions remains unclear; almost all H_2 is present in the gas phase rather than on grain surfaces, and thus the spin conversion timescale of overall H_2 (i.e., gas + solid) via the spin conversion on surfaces depends on how efficiently gaseous and solid H_2 interact.

We investigate the efficiency of the H_2 spin conversion on grain surfaces under physical conditions that are relevant to star- and planet forming regions. We utilize the rate equation model that considers adsorption of gaseous H_2 on grain surfaces which have a variety of binding sites with different potential energy depth, thermal hopping and desorption of adsorbed H_2, and the spin conversion. We find that the conversion efficiency depends on H_2 gas density and surface temperature. As a general trend, increased H_2 gas density reduces the conversion efficiency, while the temperature dependence is not monotonic; there is a critical temperature at which the efficiency is maximum. We will discuss whether the spin conversion on surfaces can dominates over that in the gas-phase in star- and planet-forming regions.

Keywords: H2 molecule, Ortho-to-para ratio, Star- and planet-forming regions

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[J] Oral | P (Space and Planetary Sciences)：P-CG Complex & General

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 201B 2F

[P-CG23] Origin and evolution of materials in space

convener:Hitoshi Miura(Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University), Hideko Nomura(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Takafumi Ootsubo(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Aki Takigawa(Division of Earth and Planetary Science, Kyoto University), Chairperson:Kenji Furuya, Yuki Hibiya

Recent progresses of astronomical observations, laboratory experiments, solar-system exploration, and theoretical work have enabled us to attempt to understand the origin and evolution of materials (dust and gas) in space in the context of material science. It is thus important to link further planetary material science and astronomy for comprehensive understanding of dust and gas in space and their role in evolution of galaxies, stars, and planetary systems. In this session, based on latest results on astronomical observations, experiments, and theoretical studies on materials in space, we discuss next steps in science for materials in space.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[PCG23-07] Thermal processes of primary silicate dust in protoplanetary disk: Constraints from oxygen isotope exchange kinetics between amorphous silicate and water vapor

★Invited Papers

*Daiki Yamamoto[1], Shogo Tachibana[2], Noriyuki Kawasaki[1], Minami Kuroda[1], Naoya Sakamoto[3], Hisayoshi Yurimoto[1,4] (1.Department of Natural History Sciences ,Hokkaido University, 2.UTokyo Organization for Planetary Space Science, The University of Tokyo , 3.Creative Research Institution, Hokkaido University , 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[PCG23-08] Birth-place of comet 17P/Holmes from its mass fractions of minerals

★Invited Papers

*Shinnaka Yoshiharu[1], Takafumi Ootsubo[2], Hideyo Kawakita[1], Mitsuru Yamaguchi[1], Mitsuhiko Honda[3], Jun-ichi Watanabe[4] (1.Kyoto Sangyo University, 2.JAXA/ISAS, 3.Kurume University, 4.NAOJ)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[PCG23-09] Comparison of grain properties in interplanetary dust from different types of parent bodies by mid-infrared spectroscopic observations with AKARI

*Aoi Takahashi[1], Takafumi Ootsubo[2], Hideo Matsuhara[2], Fumihiko Usui[3], Itsuki Sakon[4], Hiroki Chihara[5] (1.The Graduate University for Advanced Studies, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Kobe University, 4.University of Tokyo, 5.Osaka Sangyo University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[PCG23-10] Formation of forsterite crystal induced by ultraviolet irradiation of water ice ice on amorphous Mg_2SiO_4 particles

*Akira Kouchi[1], Yuki Kimura[1], Yasuhiro Oba[1], Tetsuya Hama[1], Naoki Watanabe[1], Shogo Tachibana[2], Akira Tsuchiyama[3], Satomi Enju[3], Takafumi Ootsubo[4] (1.Institute of Low Temperature Science, Hokkaido University, 2.UTokyo Organization for Planetary and Space Science, University of Tokyo, 3.Graduate School of Science, Kyoto University, 4.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[PCG23-11] Condensation experiments in the sytem Fe-Mg-Si-O-S using induction thermal plasma: implication to GEMS forming condition

*Satomi Enju[1], Hayate Kawano[1], Hisashi Komaki[2], Akira Tsuchiyama[1] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyoto University, 2.JEOL Ltd.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[PCG23-12] The initial abundance of ^{92}Nb in the outer solar system.

*Yuki Hibiya[1,2], Tsuyoshi Iizuka[2], Hatsuki Enomoto[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.The University of Tokyo)

Thermal processes of primary silicate dust in protoplanetary disk: Constraints from oxygen isotope exchange kinetics between amorphous silicate and water vapor

*Daiki Yamamoto[1], Shogo Tachibana[2], Noriyuki Kawasaki[1], Minami Kuroda[1], Naoya Sakamoto[3], Hisayoshi Yurimoto[1,4]

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Mass-independent oxygen isotope variations of extraterrestrial materials is considered to be a result of oxygen isotope exchange between ^{16}O-rich primitive materials and ^{16}O-poor gaseous reservoirs (Yurimoto & Kuramoto, 2004; Lyons & Young, 2005). Because the isotope exchange rate is controlled by the physicochemical condition of protoplanetary disks, oxygen isotopic compositions of extraterrestrial materials could be a good tracer for the disk conditions. However, little has been known about the kinetics of isotope exchange reaction for oxygen in the disks. We focused on oxygen isotope evolution of amorphous silicate dust, which is recognized as primitive material in protoplanetary disks, and investigated oxygen isotope exchange kinetics between amorphous silicates and water vapor.

A series of oxygen isotope exchange experiments between submicron-sized grains of amorphous silicate with forsterite and enstatite stoichiometry and ^{18}O-enriched water vapor (97% ^{18}O) were carried out at 803–1123 K and water vapor pressure (P_{H2O}) of 0.01–1 Pa using a gold-mirror vacuum furnace equipped with a gas flow system (Yamamoto & Tachibana, 2018). The run products were analyzed with FT-IR (JASCO FT-IR 4200), XRD (Rigaku SmartLab), and FE-SEM (JEOL JSM-7000F). The bulk oxygen isotope composition was determined as an average of multiple measurements for a pelletized sample by SIMS (Cameca ims-6f and -1280HR).

An infrared absorption peak of amorphous silicate at ~10 micron shifted to longer wavelengths with time by annealing with $H_2{}^{18}O$ vapor of 0.3 Pa at 803–883 K for amorphous forsterite and at 923–1003 K for amorphous enstatite, whereas such a shift was not observed for samples annealed in the presence of isotopically normal water vapor of 0.3 Pa. The relative peak shifts of the 10 micron feature of amorphous forsterite and enstatite correlate with their oxygen isotopic compositions, suggesting that the peak shift was caused by the isotope exchange of oxygen between amorphous silicates and $H_2{}^{18}O$ vapor. Temporal change of the degree of isotope exchange under these conditions was governed by diffusive isotope exchange with the isotope exchange rate of D ($m^2\ s^{-1}$) = (1.5 ±1.0) $\times 10^{-19}$exp[−161.5 ±14.1 (kJ mol^{-1}) R^{-1} (1/T−1/1200)] for amorphous forsterite and D ($m^2\ s^{-1}$) = (5.0 ±0.2) $\times 10^{-21}$exp[−161.3 ±1.7 (kJ mol^{-1}) R^{-1} (1/T−1/1200)] for amorphous enstatite. At P_{H2O}= 0.01 Pa, the isotope exchange reaction for amorphous forsterite is controlled by a supply of water vapor at 853 and 883 K, and the supply-controlled isotope exchange rate was evaluated. Crystallization of amorphous forsterite dominated over oxygen isotope exchange at a higher temperature of 1073 K because crystallization precedes the oxygen isotope exchange reaction. The oxygen isotope exchange timescales for amorphous forsterite and enstatite dust under protoplanetary disk conditions suggest that the primary oxygen isotope signatures of amorphous silicate dust would be erased by thermal annealing at temperatures above 500–650 K within the lifetime of protoplanetary disks.
Cometary silicate dust collected by the Stardust mission has ^{16}O-poor isotopic compositions close to the

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terrestrial value (McKeegan et al., 2006; Nakamura et al., 2008). If primitive silicate dust in the protosolar disk has the same ^{16}O-rich composition as the Sun, this observation implies that comets accreted silicate dust that was thermally processed at temperature above ~500–650 K in the inner Solar System and transported to the comet formation region (e.g., Nuth, 1999; Ciesla, 2007). This could also explain that presolar silicate grains are not a major component in cometary silicates (Floss et al., 2013). The effective radial transport of inner disk materials to the outer part of protoplanetary disks may provide some constrains on the dynamics of protoplanetary disks prior to planet formation.

Keywords: amorphous silicate, dust, oxygen, isotope exchange, protoplanetary disk

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Birth-place of comet 17P/Holmes from its mass fractions of minerals

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Comets are considered as the most pristine icy small objects in the solar system. They are likely to have kept the information about the solar system formation. Physical properties of cometary dust grains and composition of cometary volatiles are precious clues to physico-chemical conditions of the solar nebula. Comet 17P/Holmes is a Jupiter-family comet with an orbital period of ~7 yrs. Comet Holmes exhibited a great outburst starting on UT 2007 October 23 when the comet was 2.5 au from the Sun and five months after the perihelion passage. Because the observed relative abundance ratios of volatiles with respect to water in comet Holmes are enriched compared with other comets (Dello Russo et al. 2016, Icarus, 278, 301), it is thought that the nucleus of comet Holmes formed at a further distance from the Sun in the solar nebula (SN).

Silicate grains in the interstellar space are considered almost in amorphous form (only a few percent of mass or less is considered as crystalline for silicate; Kemper et al. 2004, ApJ, 609, 826). However, abundant crystalline silicate grains have often been found in cometary grains (up to ~80% by mass with large variety among comets; Hanner et al. 1994, ApJ, 425, 274; Wooden et al. 1999, ApJ, 517, 1034; Ootsubo et al. 2007, P&SS, 55, 1044, and references therein). It is thought that these crystalline silicates in comets formed by annealing of interstellar amorphous silicate grains or by direct condensation of gaseous materials in a hot region of the SN, and incorporated into cometary nuclei after they were transported to the cold comet-forming region (several to 30 au from the Sun). In this scenario, it is expected that mass fraction of the crystalline silicates in cometary dust grains tends to be smaller at further distances from the Sun.

We discuss the possibility that comet Holmes formed in a colder region in the SN rather than other comets based on the mass fraction of crystalline silicates in silicate grains. We derived mineral abundances in comet Holmes by applying the thermal emission model for cometary dust grains (Ootsubo et al. 2007, P&SS, 55, 1044; Shinnaka et al. 2018. AJ, 156, 242) to the mid-infrared spectra of comet Holmes taken with the COMICS on the Subaru Telescope from UT 2007 October 25 to 28. The derived mass fraction ratios of crystalline silicate of comet Holmes (~30%) is the almost smallest among comets studied in previous articles, supporting the hypothesis that comet Holmes formed at a further distance from the Sun in the SN compared with other comets. At such a cold region, hyper volatile ices like CO and amorphous water ices (possible energy sources for explosive sublimation) would be abundant.
This work was supported by JSPS grants (15J10864 and 17K05381).

Keywords: Comet, Mineral abundance, Mid-infrared

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Comparison of grain properties in interplanetary dust from different types of parent bodies by mid-infrared spectroscopic observations with AKARI

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Interplanetary dust (IPD) diffusely distributes in interplanetary space and is thought to be recently supplied from the inside of primordial planetesimals like asteroids or comets. The IPD’ s grain properties, such as compositions and crystal morphologies, depend on the types of parent bodies and can give us the information on the environment in the proto-solar system. The properties can be investigated in terms of silicate features around 10 μm seen in the zodiacal emission spectra. Since the IPD originating from different types of the parent bodies have different spatial distributions, it is important to survey the silicate features at various sky directions. For example, the asteroidal IPD locally distributes at low specific ecliptic latitudes and observed as band structures near the ecliptic plane. On the other hand, because of the variety of comets' inclinations, the cometary IPD distributes more globally than the asteroidal IPD does. The IPD from theJupiter Family Comets (JFCs) can form the dust cloud with a broad distribution in ecliptic latitudesaround the ecliptic plane, while the IPD from the Oort Cloud Comets (OCCs) is expected to distribute isotropically.

We obtained the high signal-to-noise zodiacal emission spectra at 74 different directions of the sky by using the mid-infrared slit-spectroscopic data obtained with the Infrared Camera on board the Japanese AKARI satellite. They exhibit the excess emission feature at the 9-12 μm range and even some sharp peaks. In order to identify the constituents, we compared the shape of spectral featureswith absorption coefficients of 4 types ofcandidate materials: amorphous with olivine composition, amorphous with pyroxene composition, forsterite (Mg2SiO4, one of olivine crystals), and ortho-enstatite (MgSiO3, one of pyroxene crystals).

The IPD was found to typicallyinclude small silicate crystals, especially enstatite grains with extreme crystal morphologies. We also found that the shape of spectral features slightly changesdependingon the sky directions.As the result of the investigation into peak wavelengths and the excess strength of each peak, the IPD at the higher ecliptic latitudes seems to have lower olivine/(olivine+pyroxene) ratio.At the sky directions toward the asteroidal dust band structures, the feature shapes show a difference which cannot be explained only by the difference in theolivine/(olivine+pyroxene) ratioand may indicate contamination of the hydrated minerals.

We will present the results of the grain properties of the IPD originating from some types of the parent bodies, and give the implications for the environment in the proto-solar system.

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Formation of forsterite crystal induced by ultraviolet irradiation of water ice ice on amorphous Mg_2SiO_4 particles

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In comets, both crystalline and amorphous silicates have been observed by infrared telescopes. It has been proposed that crystalline silicates were formed by annealing of amorphous silicates, direct condensation in hot region of proto-solar nebula, or heating due to radical recombination in organic refractory mantle. In the present study, we have experimentally investigated another possibility, heating due to radical recombination in water ice by ultraviolet (UV) irradiation.

Three amorphous silicate fine particles made by gas condensation using induction thermal plasma (ITP) were used as starting materials: Mg_2SiO_4, $MgSiO_3$, and GEM-like composition (SiO_2-rich). Amorphous fine particles were put on amorphous Si thin film (5 nm in thickness), and cooled to 10 or 82 K in ultra-high vacuum transmission electron microscope. Amorphous water ice was prepared by vapor-deposition on the sample, and irradiated with a D_2 lamp. During UV irradiation, structural change was observed by electron diffraction.

We observed the formation of forsterite crystals from amorphous Mg_2SiO_4 at 82 K, whereas the crystallization did not occur at 10 K. No crystalline phase was observed for amorphous $MgSiO_3$ and amorphous GEM-like silicate at 10 and 82 K.

These results could be explained by radical-radical recombination reactions following the photodissociation of water molecules by UV-rays, reactions (1) and (2),

$H_2O + UV \rightarrow OH + H.$ (1)

$OH + H \rightarrow H_2O + 4.8$ eV. (2)

The formation of forsterite crystals can be induced by the energy released by reaction (2) only for amorphous Mg_2SiO_4, because the value of 4.8 eV is sufficiently larger than the activation energy for crystallization of amorphous Mg_2SiO_4 (3-4 eV), but smaller than that of amorphous $MgSiO_3$ (9 eV) and amorphous GEM-like silicate. No forsterite formation at 10 K may be explained by the low mobility of H atoms and OH radicals at the ice/Mg_2SiO_4 interface at 10 K, which strongly decrease the efficiency of reaction (2) compared with 82 K.

From these results, we propose a new route for the formation of crystalline forsterite in cometary coma by solar UV irradiation with ice-covered amorphous Mg_2SiO_4 particles. Comparison with observation will be presented.

Keywords: Amorphous silicate, Photochemical reaction, Crystallzation, Forsterite

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Condensation experiments in the sytem Fe-Mg-Si-O-S using induction thermal plasma: implication to GEMS forming condition

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GEMS (Glass embedded metal and sulfides) are the major component of CP-IDPs, which are thought to be one of the most primitive materials in the solar system [1]. Synthetic experiments based on the condensation model [1] are performed to form GEMS analogue particles [2, 3], but systematic experiments including sulfur are not performed so far. In this study, synthetic experiments are performed in the system Fe-Mg-Si-O-S, with systematic change in redox condition, to understand the GEMS forming condition.

Induction thermal plasma (ITP) system was used for the condensation experiment. This system creates high temperature plasma (up to 10^4 K) which evaporates the starting material, and forms condensates in the rapid cooling environments. Plasma gas is Ar and He, with chamber pressure 70 kPa. Starting material are mixture of powder regents (SiO_2, Si, MgO, Fe, FeS_2) with GEMS mean composition [1]. Redox condition change by SiO_2/Si ratio and feeding rate (fd) of the starting material. 10 experiments are performed in total. Products were analyzed by X-ray diffraction, scanning electron microscope and transmission electron microscope.

Products were composed of fine grained condensates and coarse grained evaporation residues (1-100 μm). All condensates were formed of amorphous silicate (AS) spheres, 10-100 nm in diameter. They coexist with Fe bearing particles (<30 nm), inside and on the surface of the AS. Condensates were categorized into the following five types.

A: Fe-rich AS, including Fe metal particles

B: Fe-rich AS, with FeS particles on the surface

C: Fe-rich AS showing biphasic separation texture, with FeS particles on the surface

D: Fe-poor AS showing biphasic separation texture, with Fe particles coexisting with FeS on the surface

E: Fe-poor AS showing biphasic separation texture, with Fe_3Si (gupeiite) particle coexisting with MgS (niningerite) or FeS particles on the surface

Type A, B and C were observed in the oxidative experiment, type A and D in the intermediate experiment and type E in reductive experiment.

Formation process was considered, taking into account the grain formation process model [4]. As a basic process, AS condensates first, followed by Fe particles and finally formation of sulfides. In oxidative condition, some Fe are taken into AS as FeO (type A, B), and for the lack of Fe in gas, Fe particles did not condensate or minor condensates sulfidated into FeS (Type B, C). If there was abundant Fe in gas, Fe particles condensates on the surface of AS at relatively high temperature above glass transition temperature, and moves inside the melt before sulfidation due to surface energy (type A). In reductive

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condition, Fe is scarcely included in AS (type D, E). In type D, Fe metal particles condensates on the surface of the AS glass and partially sulfidized. Type E is the most reductive condition, Fe_3Si occurring instead of Fe metal, with MgS and FeS.

In this study, synthesized condensates had some of the features of GEMS, but condensates completely similar to GEMS (Fe-poor AS including many Fe metal particles, with FeS on the surface) was not observed. Considering the formation model in the study, GEMS is thought to be formed in the redox condition similar to type C-D. In their formation, Fe particles condensates at relatively high temperature on the surface of AS and moves inside the melt (like type A), and condensation of Fe particles continues at the surface of the AS below glass transition temperature, which is followed by sulfidation.

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Keywords: GEMS, condensation, Induction thermal plasma

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The initial abundance of ^{92}Nb in the outer solar system.

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Introduction: The *p*-process radionuclide niobium-92 (^{92}Nb) decays to zirconium-92 (^{92}Zr) by electron capture with a half-life of 37 million years (Ma). The system is a promising chronometer for addressing the early solar system evolution and planetary differentiation [1, 2]. Thus, the initial abundance of ^{92}Nb and its distribution in the early solar system provide valuable constraints on the time-scale of our solar system evolution, and on the origin of *p*-process nuclides. The initial ^{92}Nb abundance at the solar system formation was previously determined to be $(^{92}Nb/^{93}Nb)_0 = (1.7 \pm 0.6) \times 10^{-5}$, applying the internal isochron approach to the NWA 4590 angrite (U–Pb age: 4557.93 ±0.36 Ma) [2]. This value is consistent with those obtained from eucrites, ordinary chondrites, and mesosiderites [1, 3], indicating that ^{92}Nb was homogeneously distributed among their source regions. Yet, all samples previously studied for ^{92}Nb are thought to have originated from the inner solar system. Here we report internal Nb–Zr isochron dating of Northwest Africa (NWA) 6704.
NWA 6704 is a primitive achondrite having a fresh igneous texture [4] with a U–Pb age of 4562.76 ±0.30 Ma [6]. This meteorite underwent melting above liquidus temperature and subsequent rapid cooling ($> 10^{-1}$ °C/yr; [4]), making the effect of differing closure temperatures between the U–Pb and Nb–Zr systems insignificant. Furthermore, this meteorite has $\Delta^{17}O$, $\varepsilon^{50}Ti$, $\varepsilon^{54}Cr$ and $\varepsilon^{84}Sr$ values similar to those of carbonaceous chondrites [4-6], indicating that it samples the same reservoirs in the solar nebula as the carbonaceous chondrite parent bodies (i.e., the outer solar system). Thus, NWA 6704 enables us to evaluate the distribution of ^{92}Nb between the inner and outer solar system for the first time.

Results & Discussion: We prepared mineral and whole rock fractions from five fragments of NWA 6704. All Nb–Zr isotopic data were obtained by the ICP mass spectrometry. The isochron defines an initial $^{92}Nb/^{93}Nb$ of $(2.8 \pm 0.3) \times 10^{-5}$ at the time of NWA 6704 formation. By combining this value with the U–Pb age of NWA 6704, an initial $^{92}Nb/^{93}Nb$ of $(3.0 \pm 0.3) \times 10^{-5}$ at the time of solar system formation is derived. The obtained value is distinctly higher than the initial value in the inner solar system of $(1.7 \pm 0.6) \times 10^{-5}$ [2]. This indicates that ^{92}Nb was heterogeneously distributed in the protoplanetary disk before the formation of NWA 6704, and was relatively enriched in the outer solar system. The difference between these two initial values causes the apparent Nb–Zr age difference of ~30 Ma, demonstrating that the current canonical value of $(^{92}Nb/^{93}Nb)_0 = (1.7 \pm 0.6) \times 10^{-5}$ should not be used for the Nb–Zr dating of planetary materials from the outer solar system. The newly obtained initial $^{92}Nb/^{93}Nb$ value is clearly higher than the expected value in the model of ^{92}Nb synthesis by Type Ia supernova (SNIa) [7]. Thus, our results require another production site to be invoked for selectively producing ^{92}Nb. At the moment, only the ν-process in Type II supernova (SNII) [8] satisfies such requirement. If so, our finding suggests that the time-interval from the last SNII explosion to the formation of our solar system needs be <100 My and that nuclides synthesized by the last SNII were preferentially implanted or preserved in the outer solar system. Such enrichment of the last SNII components in the outer solar system may account for the isotopic dichotomy between carbonaceous and non-carbonaceous meteorites [e.g., 9].

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Keywords: niobium-92, short-lived radionuclide, p-process, ν-process, Type II supernova, isotopic dichotomy

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[J] Poster | P (Space and Planetary Sciences)：P-CG Complex & General

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_6

[P-CG23] Origin and evolution of materials in space

convener:Hitoshi Miura(Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University), Hideko Nomura(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Takafumi Ootsubo(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Aki Takigawa(Division of Earth and Planetary Science, Kyoto University)

Recent progresses of astronomical observations, laboratory experiments, solar-system exploration, and theoretical work have enabled us to attempt to understand the origin and evolution of materials (dust and gas) in space in the context of material science. It is thus important to link further planetary material science and astronomy for comprehensive understanding of dust and gas in space and their role in evolution of galaxies, stars, and planetary systems. In this session, based on latest results on astronomical observations, experiments, and theoretical studies on materials in space, we discuss next steps in science for materials in space.

[PCG23-P01] Infrared spectrum of planetary-nebula analyzed by pure-carbon graphene molecule

*Norio Ota[1] (1.University of Tsukuba,Graduate school of pure and applied sciences)

[PCG23-P02] Theory of Self-induced Desorption of Molecules from Cold Dust Surface

Tetsuo Yamamoto[1], *Hitoshi Miura[2], Osama M. Shalabiea[3] (1.Hokkaido University, 2.Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University, 3.Cairo University)

[PCG23-P03] Synthesis of GEMS analogue particles by condensation experiments in the system Mg-Fe-Si-S-Al-Ca-Ni-O

*Yuto Imura[1], Satomi Enju[1], Hayate Kawano[1], Akira Tsuchiyama[1] (1. Division of Earth and Planetary Sciences, Graduate School of Science, Kyoto University)

[PCG23-P04] Laboratory Detection of New Absorption Bands of Interstellar-Molecule Candidate Thiophenoxy Radical

Haruka Sato[1], Mayu Negishi[1], *Mitsunori Araki[1], Takahiro Oyama[1], Koichi Tsukiyama[1] (1.Department of Chemistry, Faculty of Science Division I, Tokyo University of Science)

[PCG23-P05] Structure and dynamics of interface between forsterite glass and amorphous ice

*Ayane Kubo[1], Junya Nishizawa[1], Tomoko Ikeda-Fukazawa[1] (1.Department of Applied Chemistry, Meiji University, Japan)

[PCG23-P06] Effect of Space Weathering on Identification of Organic Matter on Celestial Body Surface Using Ultraviolet Wavelength Region Spectrum

*Shogo Arao[1], Ichiro Yoshikawa[2], Kazuo Yoshioka[2], Itsuki Sakon[1], Reina Hikida[1], Izumi Endo[1], Riku Katsuse[2] (1.Graduate School of Science, The University of Tokyo, 2.Graduate School of Frontier Sciences, The University of Tokyo)

[PCG23-P07] Detection of CH_3CN in Envelope around Sagittarius B2(N)

*Mitsunori Araki[1], Shuro Takano[2], Takahiro Oyama[1], Nobuhiko Kuze[3], Kazuhisa Kamegai[4], Koichi Tsukiyama[1] (1.Tokyo University of Science, 2.Nihon University, 3.Sophia University, 4.National Astronomical Observatory of Japan)

Infrared spectrum of planetary-nebula analyzed by pure-carbon graphene molecule

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Planetary nebula is an important candidate to produce many dusts in the space. Especially, carbon-stars as like Tc1 and Lin49 show featured infrared spectrum IR [1]. It was understood that carbon fullerene (C60 and C70) could reproduce similar spectrum [2]. However, there are many extra-bands, still not identified by fullerene. We can see many graphene molecules during synthesis of fullerene in laboratory, which bring an idea to study a possibility of graphene by the first principles calculation.

We tried the quantum chemical calculation starting from model molecule of (C24) having seven carbon-hexagons using the Gaussian09 program. We applied two astrophysical conditions. One is a void creation by high speed proton, another photo-ionization by the central star. Best calculated result was obtained by graphene (C23) molecule having one carbon pentagon combined with six hexagons. Ionized states were sum of neutral, mono- and di-cations.

By an astronomical observation, we can see 16 infrared bands in a wavelength range of 5~25 micrometer [1]. Experimentally confirmed bands of fullerene (sum of C60 and C70) were 8 bands, half numbers of observed bands. In case of graphene (C23), calculated result shows that all of observed 16 bands can be reproduced very well by this calculation [3]. The reason may be high productivity of graphene from carbon gas as reported from laboratory experiments. We can suggest that graphene plays an important role in the atmosphere of the carbon-star.

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Keywords: planetary nebula, graphene, infrared spectrum

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Theory of Self-induced Desorption of Molecules from Cold Dust Surface

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The observations of interstellar molecular clouds show the presence of various species of molecules in the gas phase. Recent observations have revealed the existence of complex organic molecules and terrestrial-type organic species such as methyl formate and dimethyl ether in cold dense cores and pre-stellar cores. On the other hand, it has been pointed out that the molecules in the gas must have benn lost from the gas phase by accretion onto dust surfaces in the time shorter than the life time of dense cold clouds. This is called a freeze-out paradox. The accretion timescale is ~$10^9/n$(H) yrs, where n(H) is number density of hydrogen. This indicates that there must be some desorption mechanism to maintain the observed gas-phase abundances. Several mechanisms have been proposed so far such as temperature elevation by grain-grain collisions (d'Hedecourt et al., 1982; Schutte & Greenberg, 1991; Shalabiea & Greenberg, 1994), heating by cosmic ray, X ray and UV photons (Leger et al., 1985, Ivrev et al. 2015), and so on.

We propose a new mechanism that is necessarily associated with exothermic reactions of molecules on grain surfaces even in cold environments like cold dense cores of molecular clouds. This mechanism consists of three steps that occur on the grain surface: (1) formation of new molecules by an exothermal grain-surface reaction, (2) heating of the dust surface due to release of the heat of formation, and (3) desorption of the newly formed molecules into the gas phase.

We formulate the desorption probability of molecules newly formed by exothermic reaction by calculating the temperature distribution on the grain surface as a function of the distance from the reaction site and time. Our formula of desorption probability P is a function of heat of formation Q, desorption energy E_d of a molecule from a substrate, and molecular weight μ of a desorbing molecule. We compare P with the experiments for reactions of various Q, E_d, and μ for three substrates of oxidized HOPG, nonporous amorphous water ice, and amorphous silicate. Here, we used the compilation of the experimental data by Minissale et al. (2016). We also show a method developed for the comparison of our theory with the experiments. Discussion is given on the comparison of our theory with other two theories of desorption (Garrod et al., 2007; Minissale et al., 2016).

Keywords: Astrochemistry, Molecular cloud, Grain-surface reaction, Desorption

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Synthesis of GEMS analogue particles by condensation experiments in the system Mg-Fe-Si-S-Al-Ca-Ni-O

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GEMS (Glass with Embedded Metal and Sulfide) are main component in interplanetary dust particles with cometary origin (CP-IDPs) (Keller and Messenger, 2011). GEMS is regarded as one of the most primitive material in solar system, and thus it is important to elucidate its formation conditions and process to understand the origin of solar system. The origin of GEMS is still under debate, and several theories are proposed; formation by irradiation in interstellar region (Bradley and Dai, 2004) and condensation from gas in circumstellar regions around late-type stars or in the solar nebula (Keller and Messenger, 2011). Condensation experiments which simulate condensation process of interstellar gas have been conducted in the previous studies, and fine particles similar to GEMS have been formed (Matsuno, 2015; Kim et al., 2017; Kawano, 2019). Particularly, Kawano (2019) carried out experiments with major elements in the system Mg-Fe-Si-S-O, and showed systematical change of run product by changing redox condition. In this study, we conducted new condensation experiments in the system Mg-Fe-Si-S-Al-Ca-Ni-O, which is closer to the natural system, by adding Al, Ca, and Ni for further understanding of GEMS formation.

The experiments were performed using induction thermal plasma (ITP) system (Kyoto univ., TP-40020NPS, JEOL). As the starting materials, powders of chemical regents were mixed to make GEMS average compositions (Keller and Messenger, 2011). Three kinds of sample were made with different Si/SiO_2 ratios to change redox condition. Powder X-ray diffraction (XRD), scanning electron microscope (SEM), Fourier transform infrared spectroscopy (FT-IR), and transmission electron microscope (TEM) were used for analysis.

In XRD, halo patterns due to amorphous silicates were observed. In addition, and the peaks of different crystalline phases were observed depending on the redox conditions. Absorption due to amorphous silicate was also observed in the IR spectrum. Based on the SEM observation, the run products were divided into two types, condensates composed of fine particles (about 10-100 nm) and coarse grained evaporation residues (>1 μm). For this reason, the condensates were analyzed in detail with TEM/STEM-EDS.

Under all experimental conditions, condensates were composed by aggregates of spherical amorphous silicates particles about 10-100 nm in daiameter, which contain nanoparticles of Fe and Ni <~10 nm in size. These texturtes are similar to those of Kawano (2019) and roughly resemble natural GEMS. However, the chemical compositions of amorphous silicates and nanoparticle inclusion phases varied according to the redox conditions. In oxidizing condition, amorphous silicates were relatively Fe-rich, and (Fe, Ni) metal and Ni-rich Fe,Ni sulfide formed as nanoinclusions. In reducing condition, in contrast, amorphous silicates are poor in Fe, and Fe_3Si and FeS including minor amounts of Ni formed. Al and Ca did not form any independent phases but were homogeneously distributerd in the amorphous silicates.

Natural GEMS consists of Fe-poor amorphous silicates with Fe,Ni metal and sulfide nanoinclusions. In this experiments, any product which has exactly the same texture and mineral assembladge as GEMS was not obtained. It is expected that natural GEMS formed in an evironment between the oxidizing and reducing conditions in the present experiments.

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Keywords: GEMS, condensation experiment, system Mg-Fe-Si-S-Al-Ca-Ni-O

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Laboratory Detection of New Absorption Bands of Interstellar-Molecule Candidate Thiophenoxy Radical

Haruka Sato[1], Mayu Negishi[1], *Mitsunori Araki[1], Takahiro Oyama[1], Koichi Tsukiyama[1]

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Diffuse Interstellar Bands (DIBs) are absorption bands detected in diffuse clouds by optical observations. Although ~600 DIBs have been found so far, only the five bands were assigned to the fullerene cation and the other bands are not identified yet. Recently, benzonitrile (C_6H_5CN) was detected in interstellar space by radio as the first aromatic compound [1]. Thus, thiophenoxy radical (C_6H_5S) is received much attentions as a candidate of DIBs, because sulfur is a dominant element of interstellar molecules. For this molecule, the origin band, which is a pure electronic transition without effects of molecular vibrations, was observed as the strongest band of the $^2A_2$–X^2B_1 electronic transition [2,3]. However, our previous measurement of phenoxy radical (C_6H_5O) showed the strong vibronic bands with effects of molecular vibrations [4]. Thus, strong vibronic bands of C_6H_5S are expected because of similarity of the two molecules. We investigated the vibronic bands in the 473 –519 nm region by Cavity Ring Down spectroscopy and detected them. The strongest vibronic band at 4850 Åwas assigned to the $6a_0^2 + 6b_0^1$ transition. This band is thought to be a candidate of DIB.

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Keywords: Interstellar molecule, Diffuse Interstellar Bands, DIBs, Cavity Ring Down, thiophenoxy radical

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Structure and dynamics of interface between forsterite glass and amorphous ice

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Forsterite (Mg_2SiO_4) glass exists as dust grains in interstellar molecular clouds [1]. In interstellar molecular clouds, elements such as hydrogen, oxygen, carbon, and nitrogen deposit on the dust grains, and form various molecules (e.g., H_2O, CO, CO_2, NH_3, CH_4, H_2CO, CH_3OH, and so on) [2]. These molecules undergo chemical evolutions to organic molecules through various processes on the surface of dust grains [2]. The structure of forsterite glass is one of the important factors governing the chemical evolutions in interstellar molecular clouds. However, there are few studies for effects of coexisting molecules on the structure and properties of forsterite glass. To investigate the structure and dynamics of interface between forsterite glass and amorphous ice, molecular dynamics (MD) calculations were performed.

The MD calculations were performed using an atom-atom potential model with MXDORTO program [3]. The potential parameters were empirically determined by constraining the structure to reproduce the experimental results of density, thermal expansion coefficient, and bulk modulus [4, 5]. A fundamental orthorhombic cell consisting of 1176 Mg_2SiO_4 with two-dimensional periodic boundary conditions was used. The glass structure was prepared by quenching the liquid phase from 3000 to 10 K with 2 K/fs in rate. Then, an amorphous ice layer with 9–1580 H_2O, which was prepared by quenching a liquid phase from 290 to 10 K, was adsorbed on the glass surface. The MD code was run using NTP ensemble with constant area for the surface directions. The pressure was maintained at 0.1 MPa.

The result shows that the atomic displacement parameter (ADP) of each atomic species in forsterite (i.e., Mg, Si, and O) in the interface decreases as the number of H_2O molecules increases. For the forsterite glass without water adsorption, the ADP values of the surface layer are higher than those of internal part due to existence of dangling bonds in the surface layer [6]. To investigate the mechanisms of ADP decrease observed in the interface with amorphous ice, the structure of interface between forsterite glass and amorphous ice was analyzed. The result shows that MgO_xH_y units exist in the interface due to formation of covalent bonds between Mg and O in H_2O. The amplitude of thermal vibration of Mg decreases as the coordination number increases. The present results have important implications for the role of forsterite glass in chemical evolutions in the universe.

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Keywords: Forsterite, Amorphous ice, Interface, Molecular dynamics

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Effect of Space Weathering on Identification of Organic Matter on Celestial Body Surface Using Ultraviolet Wavelength Region Spectrum

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Analysis of reflection spectrum has been considered to be a conventional means for identifying compositions of the celestial body’s surface, but in the ultraviolet region, it has rarely been conducted. There are a few reports which suggest the existence of polycyclic aromatic hydrocarbon (PAH) in interstellar dust and on the surface of Mars’ moon Phobos on the basis of analytical results of their absorption or reflection spectrum, but the replication study is insufficient. A comparison of the spectrum of mixtures including various PAHs which exist on the earth with that of interstellar dust or the Phobos surface suggests that there are similarly shaped absorption bands at wavelengths of 210 nm and 217.5 nm respectively. This similarity of the shapes of absorption bands is the basis of the hypothesis that PAHs are present in interstellar dust and on the Phobos surface. However, considering the gap of peak wavelength, there are also many negative opinions on the hypothesis that is based on the doubtful similarity. Thus, there has been no definitive conclusion until now. One of the phenomena that may have a description for this problem is change in the absorption spectrum due to space weathering. The absorption band of PAHs around the wavelength of 210 nm is caused by the transition of aromatic π electrons. This band appears significantly in the absorption spectrum of molecules which have many bound aromatic rings, so that those orbital area of aromatic π electrons is broad. If the hydrogen atoms bonded to the aromatic rings of PAH molecules are desorbed by space weathering, it is suggested theoretically that the orbital area of aromatic π electrons is broadened and the absorption band’s peak wavelength may approach 217.5 nm. In our study, to evaluate the influence of space weathering on the optical properties of PAHs, we prepared several PAH samples which had been exposed to the space environment for about 1 year on orbit of the International Space Station (ISS). These were several of the samples loaded onto ISS’s exposure facility, ExHAM, of the Japanese experiment module, Kibo, as a research agenda, “Empirical Study on Space Weathering of Carbonaceous Solid Fine Particles and Organic Evolution”. Then, we compared the reflection characteristics of these samples with those of non-exposure samples in a wavelength region of 100-300 nm. As a result, some samples experienced space weathering tended to reflect the light in 210-300 nm wavelength region more weekly. In the presentation, evaluation and consideration of this result will be the focal points of the discussion.

Keywords: interstellar dust, Phobos, polycyclic aromatic hydrocarbon, Space Weathering

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Detection of CH_3CN in Envelope around Sagittarius B2(N)

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Traditionally used model of evolution of molecular clouds in interstellar space is described as increasing of cloud gas density from diffuse to dense conditions, i.e., from an atomic-gas cloud to a star-forming region via a diffuse cloud and a dense cloud. However, recently “reverse evolution” of molecular clouds is suggested by Price *et al.* [1]. For example, outflow from a star-forming region makes a relatively-low-density cloud. To find a clue of reverse evolution, investigation of chemical composition of relatively-low-density clouds is necessary. Absorption of CH_3CN can be observed by the hot axis effect, which shows special rotational distributions of CH_3CN in a relatively-low-density cloud [2]. In our previous work, CH_3CN was detected via absorption of the $J = 4–3$ rotational transition in the envelope of Sagittarius B2(M) core in the Galactic Center region by using Nobeyama 45-m telescope [3]. In this work, using ALMA data archive [4], we investigated absorption of the $J = 5–4$ and $6–5$ rotational transitions of CH_3CN in the envelope of Sagittarius B2(N) core, which is an adjacent core of the (M) core. The column density of CH_3CN in the envelope of the (N) core is derived to be $(1.0 \pm 0.2) \times 10^{15}$ cm^{-2}, which is 7 times larger than that in the envelope of the (M) core, while the (N) core has an 11-times larger column density than the (M) core [5]. Similar abundance relation was found in a case of HC_3N. Thus, as chemical compositions of relatively-low-density clouds, it was found that an abundant core has an abundant envelope and vice versa.

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Keywords: Sagittarius B2, CH3CN, molecular cloud, Hot Axis Effect

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[J] Poster | P (Space and Planetary Sciences)：P-CG Complex & General

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_9

[P-CG23] Origin and evolution of materials in space

convener:Hitoshi Miura(Graduate School of Natural Sciences, Department of Information and Basic Science, Nagoya City University), Hideko Nomura(Department of Earth and Planetary Sciences, Tokyo Institute of Technology), Takafumi Ootsubo(Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency), Aki Takigawa(Division of Earth and Planetary Science, Kyoto University)

Recent progresses of astronomical observations, laboratory experiments, solar-system exploration, and theoretical work have enabled us to attempt to understand the origin and evolution of materials (dust and gas) in space in the context of material science. It is thus important to link further planetary material science and astronomy for comprehensive understanding of dust and gas in space and their role in evolution of galaxies, stars, and planetary systems. In this session, based on latest results on astronomical observations, experiments, and theoretical studies on materials in space, we discuss next steps in science for materials in space.

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*Ayane Kubo[1], Junya Nishizawa[1], Tomoko Ikeda-Fukazawa[1] (1.Department of Applied Chemistry, Meiji University, Japan)

[PCG23-P06] Effect of Space Weathering on Identification of Organic Matter on Celestial Body Surface Using Ultraviolet Wavelength Region Spectrum

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[PCG23-P07] Detection of CH_3CN in Envelope around Sagittarius B2(N)

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Infrared spectrum of planetary-nebula analyzed by pure-carbon graphene molecule

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Planetary nebula is an important candidate to produce many dusts in the space. Especially, carbon-stars as like Tc1 and Lin49 show featured infrared spectrum IR [1]. It was understood that carbon fullerene (C60 and C70) could reproduce similar spectrum [2]. However, there are many extra-bands, still not identified by fullerene. We can see many graphene molecules during synthesis of fullerene in laboratory, which bring an idea to study a possibility of graphene by the first principles calculation.

We tried the quantum chemical calculation starting from model molecule of (C24) having seven carbon-hexagons using the Gaussian09 program. We applied two astrophysical conditions. One is a void creation by high speed proton, another photo-ionization by the central star. Best calculated result was obtained by graphene (C23) molecule having one carbon pentagon combined with six hexagons. Ionized states were sum of neutral, mono- and di-cations.

By an astronomical observation, we can see 16 infrared bands in a wavelength range of 5~25 micrometer [1]. Experimentally confirmed bands of fullerene (sum of C60 and C70) were 8 bands, half numbers of observed bands. In case of graphene (C23), calculated result shows that all of observed 16 bands can be reproduced very well by this calculation [3]. The reason may be high productivity of graphene from carbon gas as reported from laboratory experiments. We can suggest that graphene plays an important role in the atmosphere of the carbon-star.

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Keywords: planetary nebula, graphene, infrared spectrum

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Theory of Self-induced Desorption of Molecules from Cold Dust Surface

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The observations of interstellar molecular clouds show the presence of various species of molecules in the gas phase. Recent observations have revealed the existence of complex organic molecules and terrestrial-type organic species such as methyl formate and dimethyl ether in cold dense cores and pre-stellar cores. On the other hand, it has been pointed out that the molecules in the gas must have benn lost from the gas phase by accretion onto dust surfaces in the time shorter than the life time of dense cold clouds. This is called a freeze-out paradox. The accretion timescale is ~$10^9/n$(H) yrs, where n(H) is number density of hydrogen. This indicates that there must be some desorption mechanism to maintain the observed gas-phase abundances. Several mechanisms have been proposed so far such as temperature elevation by grain-grain collisions (d'Hedecourt et al., 1982; Schutte & Greenberg, 1991; Shalabiea & Greenberg, 1994), heating by cosmic ray, X ray and UV photons (Leger et al., 1985, Ivrev et al. 2015), and so on.

We propose a new mechanism that is necessarily associated with exothermic reactions of molecules on grain surfaces even in cold environments like cold dense cores of molecular clouds. This mechanism consists of three steps that occur on the grain surface: (1) formation of new molecules by an exothermal grain-surface reaction, (2) heating of the dust surface due to release of the heat of formation, and (3) desorption of the newly formed molecules into the gas phase.

We formulate the desorption probability of molecules newly formed by exothermic reaction by calculating the temperature distribution on the grain surface as a function of the distance from the reaction site and time. Our formula of desorption probability P is a function of heat of formation Q, desorption energy E_d of a molecule from a substrate, and molecular weight μ of a desorbing molecule. We compare P with the experiments for reactions of various Q, E_d, and μ for three substrates of oxidized HOPG, nonporous amorphous water ice, and amorphous silicate. Here, we used the compilation of the experimental data by Minissale et al. (2016). We also show a method developed for the comparison of our theory with the experiments. Discussion is given on the comparison of our theory with other two theories of desorption (Garrod et al., 2007; Minissale et al., 2016).

Keywords: Astrochemistry, Molecular cloud, Grain-surface reaction, Desorption

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Synthesis of GEMS analogue particles by condensation experiments in the system Mg-Fe-Si-S-Al-Ca-Ni-O

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GEMS (Glass with Embedded Metal and Sulfide) are main component in interplanetary dust particles with cometary origin (CP-IDPs) (Keller and Messenger, 2011). GEMS is regarded as one of the most primitive material in solar system, and thus it is important to elucidate its formation conditions and process to understand the origin of solar system. The origin of GEMS is still under debate, and several theories are proposed; formation by irradiation in interstellar region (Bradley and Dai, 2004) and condensation from gas in circumstellar regions around late-type stars or in the solar nebula (Keller and Messenger, 2011). Condensation experiments which simulate condensation process of interstellar gas have been conducted in the previous studies, and fine particles similar to GEMS have been formed (Matsuno, 2015; Kim et al., 2017; Kawano, 2019). Particularly, Kawano (2019) carried out experiments with major elements in the system Mg-Fe-Si-S-O, and showed systematical change of run product by changing redox condition. In this study, we conducted new condensation experiments in the system Mg-Fe-Si-S-Al-Ca-Ni-O, which is closer to the natural system, by adding Al, Ca, and Ni for further understanding of GEMS formation.

The experiments were performed using induction thermal plasma (ITP) system (Kyoto univ., TP-40020NPS, JEOL). As the starting materials, powders of chemical regents were mixed to make GEMS average compositions (Keller and Messenger, 2011). Three kinds of sample were made with different Si/SiO_2 ratios to change redox condition. Powder X-ray diffraction (XRD), scanning electron microscope (SEM), Fourier transform infrared spectroscopy (FT-IR), and transmission electron microscope (TEM) were used for analysis.

In XRD, halo patterns due to amorphous silicates were observed. In addition, and the peaks of different crystalline phases were observed depending on the redox conditions. Absorption due to amorphous silicate was also observed in the IR spectrum. Based on the SEM observation, the run products were divided into two types, condensates composed of fine particles (about 10-100 nm) and coarse grained evaporation residues (>1 μm). For this reason, the condensates were analyzed in detail with TEM/STEM-EDS.

Under all experimental conditions, condensates were composed by aggregates of spherical amorphous silicates particles about 10-100 nm in daiameter, which contain nanoparticles of Fe and Ni <~10 nm in size. These texturtes are similar to those of Kawano (2019) and roughly resemble natural GEMS. However, the chemical compositions of amorphous silicates and nanoparticle inclusion phases varied according to the redox conditions. In oxidizing condition, amorphous silicates were relatively Fe-rich, and (Fe, Ni) metal and Ni-rich Fe,Ni sulfide formed as nanoinclusions. In reducing condition, in contrast, amorphous silicates are poor in Fe, and Fe_3Si and FeS including minor amounts of Ni formed. Al and Ca did not form any independent phases but were homogeneously distributerd in the amorphous silicates.

Natural GEMS consists of Fe-poor amorphous silicates with Fe,Ni metal and sulfide nanoinclusions. In this experiments, any product which has exactly the same texture and mineral assembladge as GEMS was not obtained. It is expected that natural GEMS formed in an evironment between the oxidizing and reducing conditions in the present experiments.

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Keywords: GEMS, condensation experiment, system Mg-Fe-Si-S-Al-Ca-Ni-O

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Laboratory Detection of New Absorption Bands of Interstellar-Molecule Candidate Thiophenoxy Radical

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Diffuse Interstellar Bands (DIBs) are absorption bands detected in diffuse clouds by optical observations. Although ~600 DIBs have been found so far, only the five bands were assigned to the fullerene cation and the other bands are not identified yet. Recently, benzonitrile (C_6H_5CN) was detected in interstellar space by radio as the first aromatic compound [1]. Thus, thiophenoxy radical (C_6H_5S) is received much attentions as a candidate of DIBs, because sulfur is a dominant element of interstellar molecules. For this molecule, the origin band, which is a pure electronic transition without effects of molecular vibrations, was observed as the strongest band of the $^2A_2$–X^2B_1 electronic transition [2,3]. However, our previous measurement of phenoxy radical (C_6H_5O) showed the strong vibronic bands with effects of molecular vibrations [4]. Thus, strong vibronic bands of C_6H_5S are expected because of similarity of the two molecules. We investigated the vibronic bands in the 473 –519 nm region by Cavity Ring Down spectroscopy and detected them. The strongest vibronic band at 4850 Åwas assigned to the $6a_0^2 + 6b_0^1$ transition. This band is thought to be a candidate of DIB.

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Keywords: Interstellar molecule, Diffuse Interstellar Bands, DIBs, Cavity Ring Down, thiophenoxy radical

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Structure and dynamics of interface between forsterite glass and amorphous ice

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Forsterite (Mg_2SiO_4) glass exists as dust grains in interstellar molecular clouds [1]. In interstellar molecular clouds, elements such as hydrogen, oxygen, carbon, and nitrogen deposit on the dust grains, and form various molecules (e.g., H_2O, CO, CO_2, NH_3, CH_4, H_2CO, CH_3OH, and so on) [2]. These molecules undergo chemical evolutions to organic molecules through various processes on the surface of dust grains [2]. The structure of forsterite glass is one of the important factors governing the chemical evolutions in interstellar molecular clouds. However, there are few studies for effects of coexisting molecules on the structure and properties of forsterite glass. To investigate the structure and dynamics of interface between forsterite glass and amorphous ice, molecular dynamics (MD) calculations were performed.

The MD calculations were performed using an atom-atom potential model with MXDORTO program [3]. The potential parameters were empirically determined by constraining the structure to reproduce the experimental results of density, thermal expansion coefficient, and bulk modulus [4, 5]. A fundamental orthorhombic cell consisting of 1176 Mg_2SiO_4 with two-dimensional periodic boundary conditions was used. The glass structure was prepared by quenching the liquid phase from 3000 to 10 K with 2 K/fs in rate. Then, an amorphous ice layer with 9–1580 H_2O, which was prepared by quenching a liquid phase from 290 to 10 K, was adsorbed on the glass surface. The MD code was run using NTP ensemble with constant area for the surface directions. The pressure was maintained at 0.1 MPa.

The result shows that the atomic displacement parameter (ADP) of each atomic species in forsterite (i.e., Mg, Si, and O) in the interface decreases as the number of H_2O molecules increases. For the forsterite glass without water adsorption, the ADP values of the surface layer are higher than those of internal part due to existence of dangling bonds in the surface layer [6]. To investigate the mechanisms of ADP decrease observed in the interface with amorphous ice, the structure of interface between forsterite glass and amorphous ice was analyzed. The result shows that MgO_xH_y units exist in the interface due to formation of covalent bonds between Mg and O in H_2O. The amplitude of thermal vibration of Mg decreases as the coordination number increases. The present results have important implications for the role of forsterite glass in chemical evolutions in the universe.

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Keywords: Forsterite, Amorphous ice, Interface, Molecular dynamics

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Effect of Space Weathering on Identification of Organic Matter on Celestial Body Surface Using Ultraviolet Wavelength Region Spectrum

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Analysis of reflection spectrum has been considered to be a conventional means for identifying compositions of the celestial body’s surface, but in the ultraviolet region, it has rarely been conducted. There are a few reports which suggest the existence of polycyclic aromatic hydrocarbon (PAH) in interstellar dust and on the surface of Mars’ moon Phobos on the basis of analytical results of their absorption or reflection spectrum, but the replication study is insufficient. A comparison of the spectrum of mixtures including various PAHs which exist on the earth with that of interstellar dust or the Phobos surface suggests that there are similarly shaped absorption bands at wavelengths of 210 nm and 217.5 nm respectively. This similarity of the shapes of absorption bands is the basis of the hypothesis that PAHs are present in interstellar dust and on the Phobos surface. However, considering the gap of peak wavelength, there are also many negative opinions on the hypothesis that is based on the doubtful similarity. Thus, there has been no definitive conclusion until now. One of the phenomena that may have a description for this problem is change in the absorption spectrum due to space weathering. The absorption band of PAHs around the wavelength of 210 nm is caused by the transition of aromatic π electrons. This band appears significantly in the absorption spectrum of molecules which have many bound aromatic rings, so that those orbital area of aromatic π electrons is broad. If the hydrogen atoms bonded to the aromatic rings of PAH molecules are desorbed by space weathering, it is suggested theoretically that the orbital area of aromatic π electrons is broadened and the absorption band’s peak wavelength may approach 217.5 nm. In our study, to evaluate the influence of space weathering on the optical properties of PAHs, we prepared several PAH samples which had been exposed to the space environment for about 1 year on orbit of the International Space Station (ISS). These were several of the samples loaded onto ISS’s exposure facility, ExHAM, of the Japanese experiment module, Kibo, as a research agenda, “Empirical Study on Space Weathering of Carbonaceous Solid Fine Particles and Organic Evolution”. Then, we compared the reflection characteristics of these samples with those of non-exposure samples in a wavelength region of 100-300 nm. As a result, some samples experienced space weathering tended to reflect the light in 210-300 nm wavelength region more weekly. In the presentation, evaluation and consideration of this result will be the focal points of the discussion.

Keywords: interstellar dust, Phobos, polycyclic aromatic hydrocarbon, Space Weathering

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Detection of CH_3CN in Envelope around Sagittarius B2(N)

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Traditionally used model of evolution of molecular clouds in interstellar space is described as increasing of cloud gas density from diffuse to dense conditions, i.e., from an atomic-gas cloud to a star-forming region via a diffuse cloud and a dense cloud. However, recently “reverse evolution” of molecular clouds is suggested by Price *et al.* [1]. For example, outflow from a star-forming region makes a relatively-low-density cloud. To find a clue of reverse evolution, investigation of chemical composition of relatively-low-density clouds is necessary. Absorption of CH_3CN can be observed by the hot axis effect, which shows special rotational distributions of CH_3CN in a relatively-low-density cloud [2]. In our previous work, CH_3CN was detected via absorption of the $J = 4–3$ rotational transition in the envelope of Sagittarius B2(M) core in the Galactic Center region by using Nobeyama 45-m telescope [3]. In this work, using ALMA data archive [4], we investigated absorption of the $J = 5–4$ and $6–5$ rotational transitions of CH_3CN in the envelope of Sagittarius B2(N) core, which is an adjacent core of the (M) core. The column density of CH_3CN in the envelope of the (N) core is derived to be $(1.0 \pm 0.2) \times 10^{15}$ cm^{-2}, which is 7 times larger than that in the envelope of the (M) core, while the (N) core has an 11-times larger column density than the (M) core [5]. Similar abundance relation was found in a case of HC_3N. Thus, as chemical compositions of relatively-low-density clouds, it was found that an abundant core has an abundant envelope and vice versa.

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Keywords: Sagittarius B2, CH3CN, molecular cloud, Hot Axis Effect

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_3

[A-AS06] Progress in dense observation and numerical modeling of micro-scale meteorology

convener:Junshi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Kentaro Araki(Meteorological Research Institute), Jun-ichi Furumoto(Research Institute for Sustainable Humanosphere, Kyoto University), Kuniaki Higashi(Research Institute for Sustainable Humanosphere, Kyoto University Metroweather Co., Ltd.)

Recent progresses in observations and numerical simulations enable to unveil details in micro- or sub-kilometer scale meteorology. Low level convergences and heat island effects in the micro-scale may be sometimes associated with extreme atmospheric phenomena such as wind gusts and torrential rainfalls. Numerical simulations with very fine resolution may even predict occurrences of such phenomena. This session is welcome to researches and future scopes in the field of micro-scale meteorology.

[AAS06-P01] **Assimilation of Wind Profiling Radar Data in GRAPES-MESO Model System**

*Dan Wang[1], Zhen Ruan[2] (1.Numerical Weather Prediction Center, China Meteorological Administration, 2.Chinese Academy of Meteorological Sciences)

[AAS06-P02] Exploring aerosol-cloud interaction using satellite retrievals

*Xiaoyan Ma[1], hailing Jia[1], Johannes Quaas[2] (1.Nanjing University of Information Science and Technology, 2.Universität Leipzig)

[AAS06-P03] Analysis of an EF4 supercell thunderstorm mesoscale structure

*HaiGuang Zhou[1] (1.Chinese Academy of Meteorological Sciences)

[AAS06-P04] A Case Study of Seeding Condition Potential Forecast Using Cloud Resolving Model

*Yueqin SHI[1] (1.Chinese Academy of Meteorological Sciences)

[AAS06-P05] Route planning and communication of drone fleet for microscale weather observation ×

*Yuichi Yaguchi[1], Shuzo Nakano[3], Akira Sasaki[6], Masayuki Itaha[4], Tatsuya Iyobe[5], Kazuhiko Yamagishi[2] (1.The University of Aizu, 2.e-Robotics Fukushima Co., Ltd., 3.East-Japan Accounting Center Co., Ltd., 4.Japan Environment Research Co., Ltd., 5.Iyobe Shoji Ltd., 6.GClue Inc.)

[AAS06-P06] Wind speed estimation by low-cost visibility meter network

*Yui Kobayashi [1,2], Kyoya Watanabe[1,3], Nobuyasu Naruse[1,4], Yukihiro Takahashi[1,5] (1.Global Science Campus, Hokkaido University, 2.Faculty of Science, Tohoku University, 3.School of Engineering, Hokkaido University, 4.Faculty of Medicine, Shiga University of Medical Science, 5.Graduate School of Science, Hokkaido University)

[AAS06-P07] Regional characteristics of periodic variations of temperature and wind in Tokyo under wintertime nocturnal clear and weak wind conditions

*Nakajima Ko[1,2], Hideo Takahashi[2], Nobumitsu Tsunematsu[1] (1.Tokyo Metropolitan Research Institute for Environmental Protection, Tokyo Environmental Public Service Corporation, 2.Tokyo Metropolitan University)

Assimilation of Wind Profiling Radar Data in GRAPES-MESO Model System

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Based on observational datasets of the wind profiling radars (WPR) in China during July 2015, a two-step quality control procedure for the WPR data is developed. Firstly, we start from the five-beam radial velocity, and recalculate the horizontal winds. After a series of processes including the spatial consistency check, time consistency averaging and vertical wind shear check, the hourly-resolution wind datasets were finally generated with quality indicator (QI) labels. We then use the ECMWF reanalysis data and radiosonde data to evaluate the newly generated WPR data. Results show that the method used for the QI labeling performs well. When its value is greater than 50, the root mean square error of u and v components are 2.29m/s and 2.37m/s respectively. This is consistent with previous research conclusions, and confirms the reliability of the pre-processing algorithm. Secondly, a second-round quality control based on the data assimilation is conducted. This procedure includes (1) removing the wind filed data located below the GRAPES model terrain, (2) configuring the effective height, (3) background check and (4) vertical thinning. The distributions of the innovations corresponding to observations after the QC are more close to a Gaussian distribution. The WPR observations after the QC were used in one-month continuous experiments based on the GRAPES modeling system. Results show that the assimilation of wind profiling radar data can effectively improve the wind state in the initial conditions. The corresponding 0-24h forecast of wind performs better. An analysis of 6-hourly verification scores like ETS and BIAS of the precipitation field suggests that the assimilation of wind profiling radar data makes a positive contribution to the rainfall forecast, especially in the short-range forecasting within 12 hours. The impact of assimilating WPR data on the case of typhoon “Linfa” is also investigated in this study. Results show that assimilating WPR data can effectively adjust the dynamic structure and water vapor conditions over the typhoon precipitation area, forming more favorable conditions for development of convective system and improving the forecast skill of precipitation.

Keywords: Wind profiling radar, Quality control, GRAPES-3DVAR, Impact experiment

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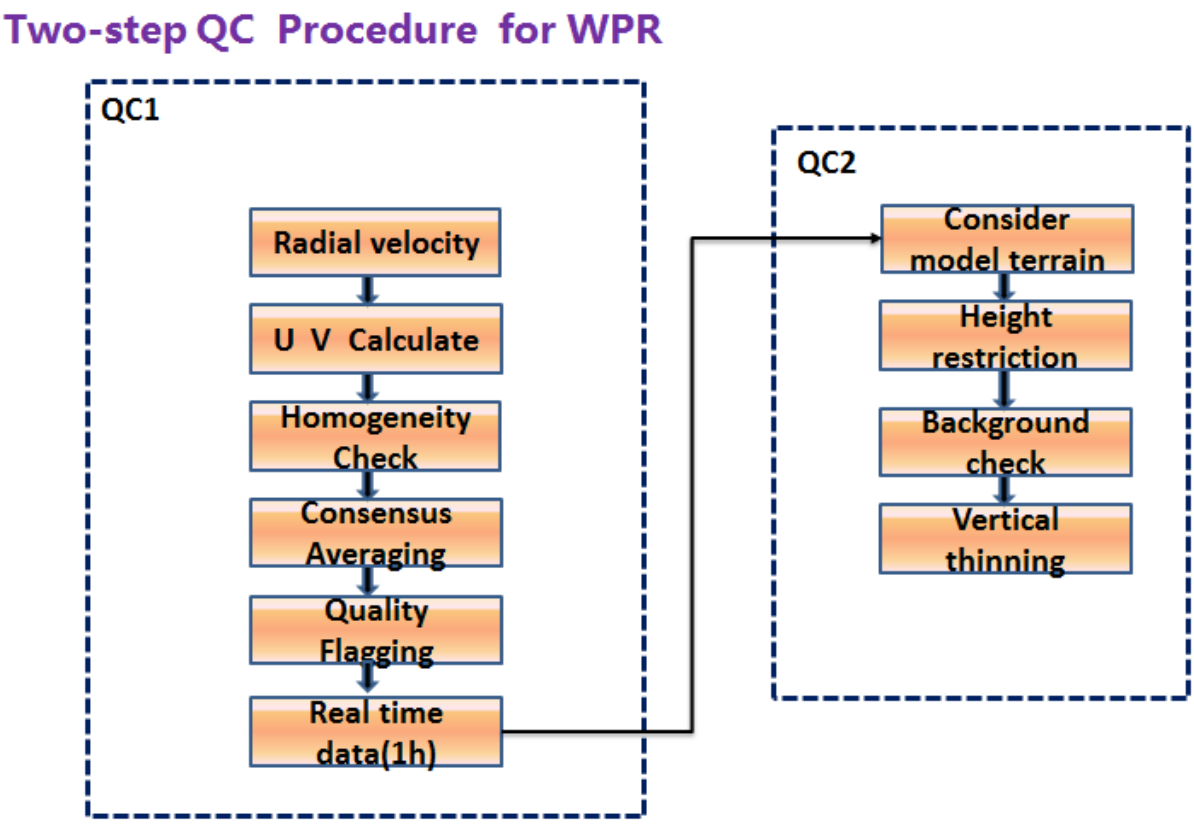

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Exploring aerosol-cloud interaction using satellite retrievals

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Long term MODIS level 3 data (MYD08_D3) from 2003 to 2016 was employed to investigate the correlation between aerosol and cloud properties over three major industrial regions in northern hemisphere (NH) and their adjacent oceans. Statistical analysis indicate that for liquid cloud, strong positive correlation between aerosol optical depth (AOD) and cloud effective radius (CER) is found over east China, i.e. CER increases with AOD, but becomes weak over east US and obscure over west Europe. In contrast, consistent negative correlation (i.e. CER decreases with AOD) is found over three adjacent oceans. Cloud properties such as cloud fraction (CF), cloud optical depth (COD), and liquid water path (LWP) and their relations with AOD were also examined. To understand the mechanisms leading to these findings, the ERA-interim reanalysis data was employed to investigate the impacts of lower tropospheric stability, vertical velocity, and precipitable water on the correlations between AOD and cloud properties. Possible explanations were discussed.

Keywords: aerosol, cloud, satellite retrievals

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Analysis of an EF4 supercell thunderstorm mesoscale structure

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The Enhanced Fujita 4 (EF4) Scale tornado outbroken in Funing county on 23 June 2016, was the strongest tornado in Jiangsu province since 1961. This paper addressed the synoptic environment, the thermodynamic condition, and the three-dimensional fine scale structure of the tornadic supercell thunderstorm. This thunderstorm developed under a convectively unstable environmental condition. The environmental wind vertical shear was intense at the low and middle level. Convergence lines and a γ -mesoscale cyclone were observed on the surface. The supercell thunderstorm was a left-moving supercell with a hook echo and an inflow notch at the low level. A strong mesocyclone, located in the top of the hook echo, was observed clearly in Doppler radar image at the low and middle level. It lasted for more than 90 minutes. The tornado vortex signature (TVS) lasted for 12 volume scans, which was 46 minutes before the tornado occurred. In the period of tornado formation and intensification, the center of the storm mass, the storm top, and the height of the maximum reflectivity rose remarkably. The vertical integrated liquid (VIL) of the storm increased, too. The tornado occurred in the first time of the above-mentioned parameters decreased synchronously. The dual-Doppler retrieval wind fields revealed a mesocyclone at the low level of the convective storm. This mesocyclone was situated at the low and middle level of the hook echo high-reflectivity region. Moreover, a weaker anticyclonic circulation was located on the south of mesocyclone. The vertical vorticity couplets played an important role in the tornado formation, intensification, and maintenance.

Keywords: Tornado, Mesocyclone, Supercell thunderstorm

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A Case Study of Seeding Condition Potential Forecast Using Cloud Resolving Model

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The cloud precipitation explicit forecast system (CPEFS_V1.0) was used to forecast the seeding condition potential on celebrating activities for the 70th anniversary of the founding of Inner Mongolia Autonomous Region. The results showed that due to eastward movement of short wave trough and low-level shear line, water vapor condition in Hohhot region was better, unstable energy was higher, and convective weather was easy to trigger. In the morning of Aug. 8, 2017, convective clouds were appeared in the northwest direction of the core zone. Convective clouds rapidly developed and moved eastward and southward to the core zone. Lifetime of convective clouds was about 1.5-3 hours, and horizontal scale was about tens of kilometers. The generation time of convective clouds of forecast was 1-2 hours later than the observation, and moving direction was consistent with observation. Moving speed was 10-20 $km \cdot h^{-1}$ slower. Convective clouds had vertical structure of cold-warm mixed clouds, with large updraft, high content of snow and graupel, low cloud water content in warm regions, cloud top height of 10 km, cloud bottom height of 3 km, 0℃ height of 4.3 km, maximum content of supercooled water of 0.7 $g \cdot kg^{-1}$, less ice crystals in areas with rich supercooled water, these characteristics were consistent with satellite, radar and airborne detection. In the afternoon of Aug. 7, key defense zone was chosen to the west of the core zone. AgI over-seeding would be implemented during 5100 –7000 m height. In the morning of Aug. 8, the aircraft would carry out detection in weak echo area of the first defense line. Ground operations would focus on the implementation of over-seeding in the initial stage of convective clouds in the third defense line to achieve the goal of mitigation rainfall. Based on forecast, additional five sets of ground mobile seeding equipment had been added temporarily to reinforce the capability of rain mitigation operated on Aug. 8. Seeding condition for the 70th anniversary celebration was better forecast.

Keywords: seeding condition potential forecast, seeding operation plan, convective cloud precipitation, major activity guarantee, weather modification

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Route planning and communication of drone fleet for microscale weather observation ×

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1. The University of Aizu, 2. e-Robotics Fukushima Co., Ltd., 3. East-Japan Accounting Center Co., Ltd., 4. Japan Environment Research Co., Ltd., 5. Iyobe Shoji Ltd., 6. GClue Inc.

This research considers the operation and communication of the drone in the case of actually carrying out microscale fixed point observation using the drone fleet. In the case of using multiple drones at the same time, some applications were proposed in the field of entertainment and already commercialized such as the Intel 500. In these entertainment drone fleet has 1% to 5% of the drone will not crash, take off or may be unintentionally briefly beneath. In order to avoid unforeseen circumstances caused by these, in addition to miniaturization, such as 500 g or less in these drone, countermeasures such as attaching a frame are carried out. However, when the plane flying at a height of 1000 m to 2000 m where clouds can be formed, it is not necessary to use a large drone with a wind resistance of about 20 m / s, and in the assumed coastal area measurement, the sea will be directly below. In these situations, we need to design a system that guarantees the drones' completeness, but can return safely if there is a deficiency.

When sending 27 drones to a fixed point of 3 x 3 x 3, even if there are problems to crash and drop in the middle of the process, the flight path management should be excluding the two-dimensional intersection. We consider these kind of path planning which the drones are safe to flight all process from the taking off to landing. The requirement of the takeoff sequence, the drones should be enough to tight to set small area, but it should not affect propeller wind such as from 3 to 4 m lattice form. Also, we should divide the flight group because to make safety. A drone group should away from the Knight-jump and take off for each group. From there we moved to a pool that opened horizontally in a row and we aimed at the destination from there so that we avoided two dimensional intersections at long drone flight.

In addition, for the long range telemetry system of drones, we constructed a 920 MHz power saving small radio using the LoRa modulation scheme, define the data payload, aggregate each data once per second While allowing commands such as feedback from the ground station to be entered. This telemetry system can obtain the information such as the latitude, longitude, and altitude of the current position of the drone from the GPS of the drone body, the data payload includes data on wind direction, wind power, temperature, pressure and humidity acquired from the weather observation device, and any additional sensor with reservation data section corresponding to 20 bits is provided.

In this fiscal year's verification, at the Fukushima Robot Test Field, we verified whether 3 x 3 x 3 row flight is possible at intervals of 40 m, 70 m, 100 m at 30 m intervals, up to an altitude of 100 m. As a result, while occasionally there was a drone descending due to the turbulence of the airflow, we were able to hover at a fixed point while maintaining a sufficiently safe airspace. With respect to communication, if the distance is about 150 m straight, the collision due to the carrier sense in only 1 channel in a one second period when spreading at a spreading factor of 7 and frequency band of 500 kHz and performing communication for 28 units is 10% or less is there. When it is replaced with a distance of about 3 km in a straight line, communication with radio wave intensity of 20 mW is possible for each single unit, but since the communication speed problem arises, it is necessary to try with the radio wave intensity of 250 mW in the next fiscal year.

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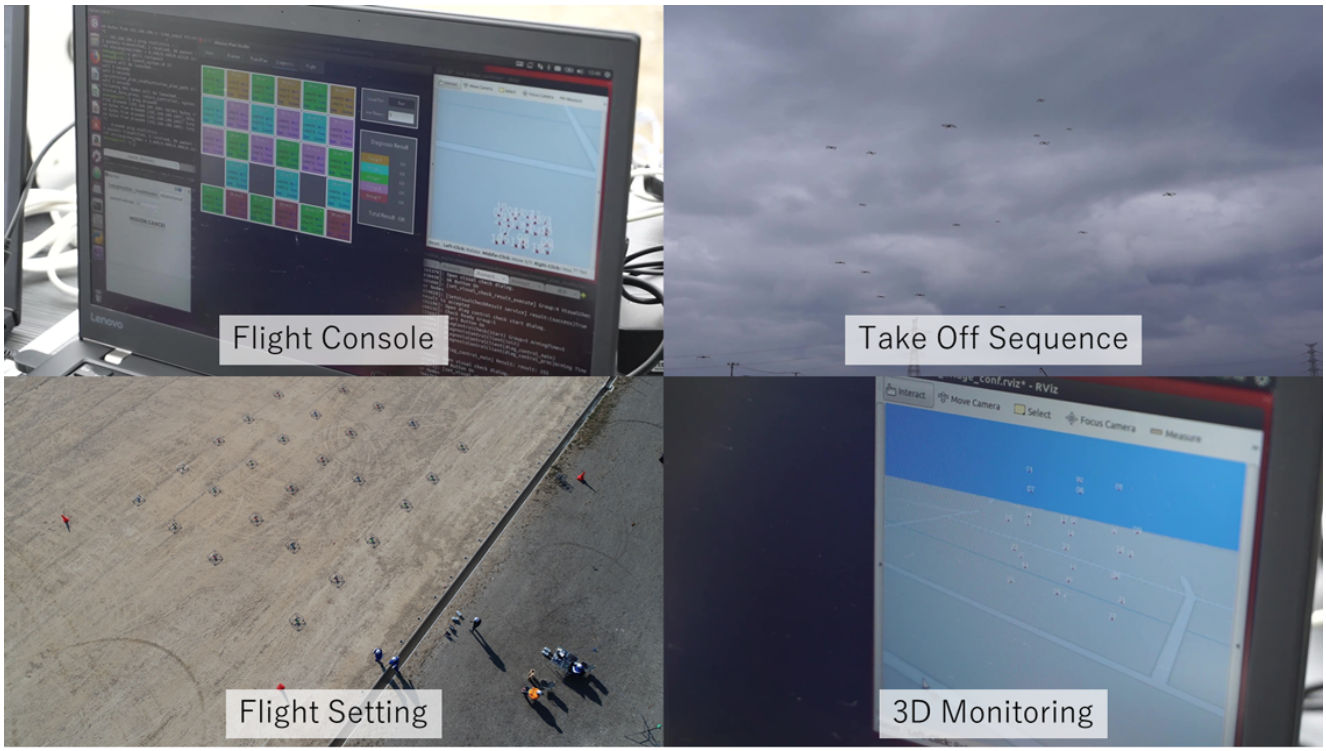
Keywords: Drone fleet, Wireless Communication, Observation System



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Wind speed estimation by low-cost visibility meter network

*Yui Kobayashi [1,2], Kyoya Watanabe[1,3], Nobuyasu Naruse[1,4], Yukihiro Takahashi[1,5]

1. Global Science Campus, Hokkaido University, 2. Faculty of Science, Tohoku University, 3. School of Engineering, Hokkaido University, 4. Faculty of Medicine, Shiga University of Medical Science, 5. Graduate School of Science, Hokkaido University

Poor-visibility with the blowing snow sometimes causes serious troubles such as car crashes. Previously we reported the development of a low-cost visibility meter, which estimates visibility quantitatively, measuring the reduction of laser intensity caused by the laser blocking by snow particles. Those laser intensity data together with ambient temperature are sent to a personal computer via a wireless network. The remarkable characteristic of this apparatus is a very compact body, achieving enough length of the light path by reflecting laser light three times by mirrors facing each other. We confirmed the performance as poor-visibility meter, by investigating the correlation between the reduction of laser intensity and the visibility simultaneously recorded by the conventional video system.
In regard to wind speed, which is essential in order to predict poor-visibility caused by blowing snow, conventional propeller-type anemometer has been used up to now. However, such propeller anemometer has moving parts so that the low-cost type lacks durability. On the other hand, the hot-wire and thermocouple type anemometer needs relatively high-power consumption. In this study we developed a new methodology for wind speed measurement using densely placed visibility meters, making use of the time difference between the snow particle passing at different apparatus. Experiments were performed using a wind tunnel at Cryospheric Environment Simulator of the Shinjo Branch (Snow and Ice Research Center, National Research Institute for Earth Science and Disaster Resilience). The three units of the visibility meter were set at an interval of 4-5 m in the wind tunnel and connected with a computer for data collections by wireless communication. The time interval of data sampling was set to 0.5 s. The propeller type anemometer to measure the wind speed as a reference was set downstream of the three observation units. The wind speed can be measured by detecting the delay time for snow particles to move from one unit to the next one. The wind speed obtained by our system was 8.8 m s^{-1}, being averaged for data obtained at three points, while the wind speed measured by the anemometer was 9.1 m s^{-1}. These results mean only with this poor-visibility meter network we can estimate the wind velocity with an accuracy of 3 percent.

Keywords: Blowing snow, Disaster Prevention, Instrument Development

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Regional characteristics of periodic variations of temperature and wind in Tokyo under wintertime nocturnal clear and weak wind conditions

*Nakajima Ko[1,2], Hideo Takahashi[2], Nobumitsu Tsunematsu[1]

1. Tokyo Metropolitan Research Institute for Environmental Protection, Tokyo Environmental Public Service Corporation, 2. Tokyo Metropolitan University

Intermittent turbulence on time scales of a few minutes to 1 h is often observed in the nocturnal boundary layers. Previous observations were limited to one location (Yokoyama et al. 1981), or to homogeneous topographies within hundreds of square meters (Sun et al. 2015). The regional characteristics of these wavelike motions are unclear in metropolitan areas or in heterogeneous rural-urban areas that can be characterized by different surface conditions. Fujibe (2018) showed the climatological features of surface air temperature variations using 1 min data of the Automated Meteorological Data Acquisition System (AMeDAS) in Japan at horizontal intervals of approximately 17 km. In the Tokyo special wards, 1 min temperature and wind data have been recorded by the Air Pollution Monitoring Systems (APMS) at horizontal intervals of approximately 4.7 km. Therefore, these data can be used to analyze the characteristics of temperature and wind variations on time scales of 1 h or less and expected to investigate the regional characteristics of the variations in this area. The purpose of this study is to elucidate the temporal variations of temperature and wind and their regional characteristics over the Tokyo metropolitan area.

One-minute temperature, wind direction, and wind speed data from November 2016 to February 2017 obtained from the 44 APMS stations were used in this study. Additionally, the hourly wind speed, wind direction, cloud amounts, and precipitation data at the Tokyo District Meteorological Observatory (Kitanomaru) were used. We selected 17 clear and weak wind nights over the observation period using observational data at Kitanomaru by the same process as Nakajima et al. (2018).

The periodic variations of temperature and wind developed at several observational stations in several clear and weak winds nights. Especially, the periodic variations clearly developed on January 11-12, 2017. The winds and temperature fluctuated periodically in the western part of the Tokyo special wards from January 11 23:00 to 02:00 JST. The cycles of the variations were estimated as 20-50 mins from the wavelet analysis and were 5-10 times longer than that of the Brunt-Vaisala oscillation. This ratio agrees with the previous observational results (Yokoyama et al. 1981). On the contrary, the periodic variations were unclear in the central of the Tokyo special wards area such as Chiyoda ward.

In order to examine the regional characteristics of temporal variation of temperature, 20-50 mins band-pass filter was used to the temperature time series from 18:00 to 06:00 JST in each clear and weak wind night. The amplitudes of the band-passed filtered temperature variations in the non-urban area tended to be larger than 0.2˚C. However, the amplitudes in the urban area tended to be smaller than those in a non-urban area.

The difference of the temporal variations between the urban area and the non-urban area implies that the difference of the atmospheric stability between the urban area and the non-urban area. Over a non-urban area at nighttime, ground-based inversion layer grows. However, over an urban area, the atmospheric stability tends to be near neutral (Oke et al. 2017). Small turbulence might produce a large temperature variation under a strong inversion layer, whereas the amplitude is expected to be small under a weak inversion layer (Fujibe 2018). Therefore, the smaller amplitude over urban area might develop under near neutral atmospheric stability.

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Keywords: boundary layer, temperature variation, wind variation

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_10

[A-AS06] Progress in dense observation and numerical modeling of micro-scale meteorology

convener:Junshi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Kentaro Araki(Meteorological Research Institute), Jun-ichi Furumoto(Research Institute for Sustainable Humanosphere, Kyoto University), Kuniaki Higashi(Research Institute for Sustainable Humanosphere, Kyoto University Metroweather Co., Ltd.)

Recent progresses in observations and numerical simulations enable to unveil details in micro- or sub-kilometer scale meteorology. Low level convergences and heat island effects in the micro-scale may be sometimes associated with extreme atmospheric phenomena such as wind gusts and torrential rainfalls. Numerical simulations with very fine resolution may even predict occurrences of such phenomena. This session is welcome to researches and future scopes in the field of micro-scale meteorology.

[AAS06-P01] Assimilation of Wind Profiling Radar Data in GRAPES-MESO Model System

*Dan Wang[1], Zhen Ruan[2] (1.Numerical Weather Prediction Center, China Meteorological Administration, 2.Chinese Academy of Meteorological Sciences)

[AAS06-P02] Exploring aerosol-cloud interaction using satellite retrievals

*Xiaoyan Ma[1], hailing Jia[1], Johannes Quaas[2] (1.Nanjing University of Information Science and Technology, 2.Universität Leipzig)

[AAS06-P03] Analysis of an EF4 supercell thunderstorm mesoscale structure

*HaiGuang Zhou[1] (1.Chinese Academy of Meteorological Sciences)

[AAS06-P04] A Case Study of Seeding Condition Potential Forecast Using Cloud Resolving Model

*Yueqin SHI[1] (1.Chinese Academy of Meteorological Sciences)

[AAS06-P05] Route planning and communication of drone fleet for microscale weather observation ×

*Yuichi Yaguchi[1], Shuzo Nakano[3], Akira Sasaki[6], Masayuki Itaha[4], Tatsuya Iyobe[5], Kazuhiko Yamagishi[2] (1.The University of Aizu, 2.e-Robotics Fukushima Co., Ltd., 3.East-Japan Accounting Center Co., Ltd., 4.Japan Environment Research Co., Ltd., 5.Iyobe Shoji Ltd., 6.GClue Inc.)

[AAS06-P06] Wind speed estimation by low-cost visibility meter network

*Yui Kobayashi [1,2], Kyoya Watanabe[1,3], Nobuyasu Naruse[1,4], Yukihiro Takahashi[1,5] (1.Global Science Campus, Hokkaido University, 2.Faculty of Science, Tohoku University, 3.School of Engineering, Hokkaido University, 4.Faculty of Medicine, Shiga University of Medical Science, 5.Graduate School of Science, Hokkaido University)

[AAS06-P07] Regional characteristics of periodic variations of temperature and wind in Tokyo under wintertime nocturnal clear and weak wind conditions

*Nakajima Ko[1,2], Hideo Takahashi[2], Nobumitsu Tsunematsu[1] (1.Tokyo Metropolitan Research Institute for Environmental Protection, Tokyo Environmental Public Service Corporation, 2.Tokyo Metropolitan University)

Assimilation of Wind Profiling Radar Data in GRAPES-MESO Model System

*Dan Wang[1], Zhen Ruan[2]

1. Numerical Weather Prediction Center, China Meteorological Administration, 2. Chinese Academy of Meteorological Sciences

Based on observational datasets of the wind profiling radars (WPR) in China during July 2015, a two-step quality control procedure for the WPR data is developed. Firstly, we start from the five-beam radial velocity, and recalculate the horizontal winds. After a series of processes including the spatial consistency check, time consistency averaging and vertical wind shear check, the hourly-resolution wind datasets were finally generated with quality indicator (QI) labels. We then use the ECMWF reanalysis data and radiosonde data to evaluate the newly generated WPR data. Results show that the method used for the QI labeling performs well. When its value is greater than 50, the root mean square error of u and v components are 2.29m/s and 2.37m/s respectively. This is consistent with previous research conclusions, and confirms the reliability of the pre-processing algorithm. Secondly, a second-round quality control based on the data assimilation is conducted. This procedure includes (1) removing the wind filed data located below the GRAPES model terrain, (2) configuring the effective height, (3) background check and (4) vertical thinning. The distributions of the innovations corresponding to observations after the QC are more close to a Gaussian distribution. The WPR observations after the QC were used in one-month continuous experiments based on the GRAPES modeling system. Results show that the assimilation of wind profiling radar data can effectively improve the wind state in the initial conditions. The corresponding 0-24h forecast of wind performs better. An analysis of 6-hourly verification scores like ETS and BIAS of the precipitation field suggests that the assimilation of wind profiling radar data makes a positive contribution to the rainfall forecast, especially in the short-range forecasting within 12 hours. The impact of assimilating WPR data on the case of typhoon “Linfa” is also investigated in this study. Results show that assimilating WPR data can effectively adjust the dynamic structure and water vapor conditions over the typhoon precipitation area, forming more favorable conditions for development of convective system and improving the forecast skill of precipitation.

Keywords: Wind profiling radar, Quality control, GRAPES-3DVAR, Impact experiment

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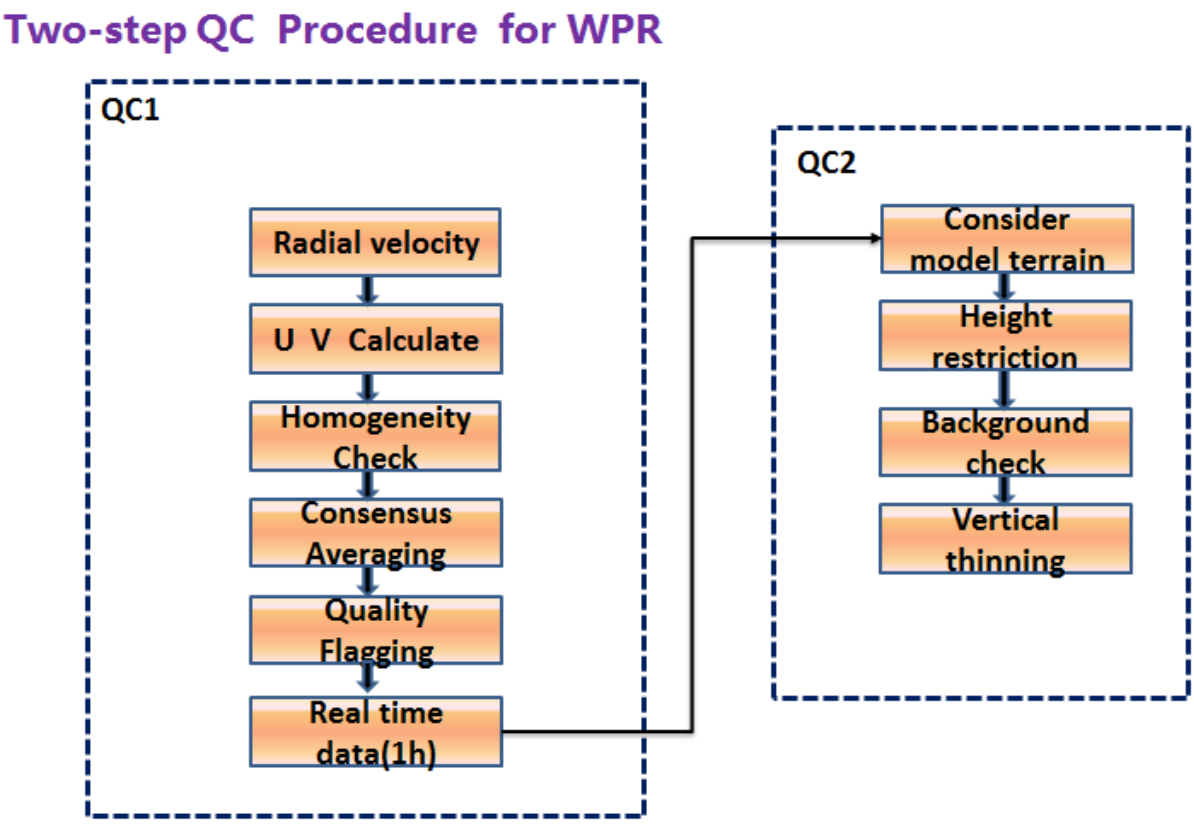

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Exploring aerosol-cloud interaction using satellite retrievals

*Xiaoyan Ma[1], hailing Jia[1], Johannes Quaas[2]

1. Nanjing University of Information Science and Technology, 2. Universität Leipzig

Long term MODIS level 3 data (MYD08_D3) from 2003 to 2016 was employed to investigate the correlation between aerosol and cloud properties over three major industrial regions in northern hemisphere (NH) and their adjacent oceans. Statistical analysis indicate that for liquid cloud, strong positive correlation between aerosol optical depth (AOD) and cloud effective radius (CER) is found over east China, i.e. CER increases with AOD, but becomes weak over east US and obscure over west Europe. In contrast, consistent negative correlation (i.e. CER decreases with AOD) is found over three adjacent oceans. Cloud properties such as cloud fraction (CF), cloud optical depth (COD), and liquid water path (LWP) and their relations with AOD were also examined. To understand the mechanisms leading to these findings, the ERA-interim reanalysis data was employed to investigate the impacts of lower tropospheric stability, vertical velocity, and precipitable water on the correlations between AOD and cloud properties. Possible explanations were discussed.

Keywords: aerosol, cloud, satellite retrievals

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Analysis of an EF4 supercell thunderstorm mesoscale structure

*HaiGuang Zhou[1]

1. Chinese Academy of Meteorological Sciences

The Enhanced Fujita 4 (EF4) Scale tornado outbroken in Funing county on 23 June 2016, was the strongest tornado in Jiangsu province since 1961. This paper addressed the synoptic environment, the thermodynamic condition, and the three-dimensional fine scale structure of the tornadic supercell thunderstorm. This thunderstorm developed under a convectively unstable environmental condition. The environmental wind vertical shear was intense at the low and middle level. Convergence lines and a γ -mesoscale cyclone were observed on the surface. The supercell thunderstorm was a left-moving supercell with a hook echo and an inflow notch at the low level. A strong mesocyclone, located in the top of the hook echo, was observed clearly in Doppler radar image at the low and middle level. It lasted for more than 90 minutes. The tornado vortex signature (TVS) lasted for 12 volume scans, which was 46 minutes before the tornado occurred. In the period of tornado formation and intensification, the center of the storm mass, the storm top, and the height of the maximum reflectivity rose remarkably. The vertical integrated liquid (VIL) of the storm increased, too. The tornado occurred in the first time of the above-mentioned parameters decreased synchronously. The dual-Doppler retrieval wind fields revealed a mesocyclone at the low level of the convective storm. This mesocyclone was situated at the low and middle level of the hook echo high-reflectivity region. Moreover, a weaker anticyclonic circulation was located on the south of mesocyclone. The vertical vorticity couplets played an important role in the tornado formation, intensification, and maintenance.

Keywords: Tornado, Mesocyclone, Supercell thunderstorm

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A Case Study of Seeding Condition Potential Forecast Using Cloud Resolving Model

*Yueqin SHI[1]

1. Chinese Academy of Meteorological Sciences

The cloud precipitation explicit forecast system (CPEFS_V1.0) was used to forecast the seeding condition potential on celebrating activities for the 70th anniversary of the founding of Inner Mongolia Autonomous Region. The results showed that due to eastward movement of short wave trough and low-level shear line, water vapor condition in Hohhot region was better, unstable energy was higher, and convective weather was easy to trigger. In the morning of Aug. 8, 2017, convective clouds were appeared in the northwest direction of the core zone. Convective clouds rapidly developed and moved eastward and southward to the core zone. Lifetime of convective clouds was about 1.5-3 hours, and horizontal scale was about tens of kilometers. The generation time of convective clouds of forecast was 1-2 hours later than the observation, and moving direction was consistent with observation. Moving speed was 10-20 $km \cdot h^{-1}$ slower. Convective clouds had vertical structure of cold-warm mixed clouds, with large updraft, high content of snow and graupel, low cloud water content in warm regions, cloud top height of 10 km, cloud bottom height of 3 km, 0℃ height of 4.3 km, maximum content of supercooled water of 0.7 $g \cdot kg^{-1}$, less ice crystals in areas with rich supercooled water, these characteristics were consistent with satellite, radar and airborne detection. In the afternoon of Aug. 7, key defense zone was chosen to the west of the core zone. AgI over-seeding would be implemented during 5100 –7000 m height. In the morning of Aug. 8, the aircraft would carry out detection in weak echo area of the first defense line. Ground operations would focus on the implementation of over-seeding in the initial stage of convective clouds in the third defense line to achieve the goal of mitigation rainfall. Based on forecast, additional five sets of ground mobile seeding equipment had been added temporarily to reinforce the capability of rain mitigation operated on Aug. 8. Seeding condition for the 70th anniversary celebration was better forecast.

Keywords: seeding condition potential forecast, seeding operation plan, convective cloud precipitation, major activity guarantee, weather modification

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Route planning and communication of drone fleet for microscale weather observation ×

*Yuichi Yaguchi[1], Shuzo Nakano[3], Akira Sasaki[6], Masayuki Itaha[4], Tatsuya Iyobe[5], Kazuhiko Yamagishi[2]

1. The University of Aizu, 2. e-Robotics Fukushima Co., Ltd., 3. East-Japan Accounting Center Co., Ltd., 4. Japan Environment Research Co., Ltd., 5. Iyobe Shoji Ltd., 6. GClue Inc.

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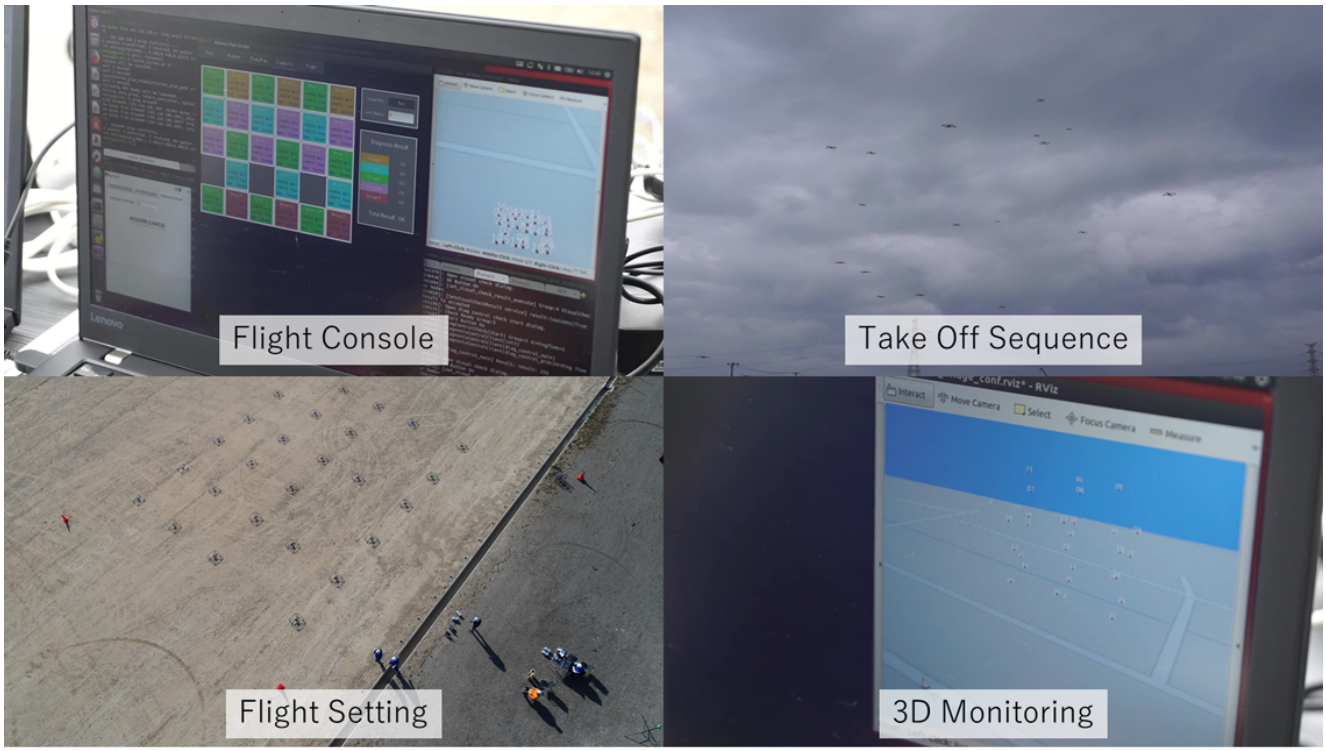

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Poor-visibility with the blowing snow sometimes causes serious troubles such as car crashes. Previously we reported the development of a low-cost visibility meter, which estimates visibility quantitatively, measuring the reduction of laser intensity caused by the laser blocking by snow particles. Those laser intensity data together with ambient temperature are sent to a personal computer via a wireless network. The remarkable characteristic of this apparatus is a very compact body, achieving enough length of the light path by reflecting laser light three times by mirrors facing each other. We confirmed the performance as poor-visibility meter, by investigating the correlation between the reduction of laser intensity and the visibility simultaneously recorded by the conventional video system.
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Keywords: boundary layer, temperature variation, wind variation

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-AS Atmospheric Sciences, Meteorology & Atmospheric Environment

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 301A 3F

[A-AS06] Progress in dense observation and numerical modeling of micro-scale meteorology

convener:Junshi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Kentaro Araki(Meteorological Research Institute), Jun-ichi Furumoto(Research Institute for Sustainable Humanosphere, Kyoto University), Kuniaki Higashi(Research Institute for Sustainable Humanosphere, Kyoto University Metroweather Co., Ltd.), Chairperson:Junshi Ito(The University of Tokyo), Kentaro Araki(Meteorological Research Institute)

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1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AAS06-01] A Linear Array of Wind and Pressure Sensors for High Resolution in situ Measurements in Winter Tornadoes

★Invited Papers

*Kusunoki Kenichi[1], Hanako Inoue[1], Naoki Ishitsu[2], Chusei Fujiwara[3] (1.Meteorological Research Institute, 2.Alpha-denshi Co., Ltd. / Meteorological Research Institute, 3.East Japan Railway Company)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AAS06-02] Mesoscale fixed point weather observation architecture by Drone fleet

*Yuichi Yaguchi[1], Masayuki Itaha[4], Shuzo Nakano[3], Kazuhiko Yamagishi[2], Tatsuya Iyobe[5] (1.The University of Aizu, 2.e-Robotics Fukushima Co., Ltd., 3.East-Japan Accounting Center Co., Ltd., 4.Japan Environment Research Co., Ltd., 5.Iyobe Shoji Ltd.)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AAS06-03] Potential of dense weather event observation using surface optical fiber cable and DAS technology

*Tsunehisa KIMURA[1] (1.Schlumberger)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AAS06-04] Case study of environmental conditions and cloud microphysical properties of winter convective clouds developed in the Kanto plain

*Kentaro Araki[1], Shinsuke Satoh[2], Takuya Tajiri[1] (1.Meteorological Research Institute, 2.National Institute of Information and Communications Technology)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AAS06-05] Numerical simulation of the urban effect on the atmospheric boundary layer structure in Tokyo using the SPUC urban canopy scheme

*Naoko Seino[1] (1.Meteorological Research Institute)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AAS06-06] Surface layer model for instantaneous wind speeds designed by deep learning

*Junshi Ito[1,2], Hideaki Mouri[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo , 2.Meteorological Research Institute)

A Linear Array of Wind and Pressure Sensors for High Resolution in situ Measurements in Winter Tornadoes

*Kusunoki Kenichi[1], Hanako Inoue[1], Naoki Ishitsu[2], Chusei Fujiwara[3]

1. Meteorological Research Institute, 2. Alpha-denshi Co., Ltd. / Meteorological Research Institute, 3. East Japan Railway Company

The Shonai area railroad weather project has investigated fine-scale structure of wind gust dynamics and kinetics such as tornadoes, downbursts, and gust fronts. As part of the project, in order to improve our understanding of near-surface tornadic features, we developed a linear array of wind and pressure sensors (**LAWPS**: **L**inear **A**rray of **W**ind and **P**ressure **S**ensors) for high resolution in situ measurements in winter tornado cores. The wind and pressure sensors were deployed along a 1.2-km-long linear array that is located parallel to and about 100m from the shoreline. Wind data are obtained using 12 two-dimensional fast-response ultrasonic anemometers placed at a height of 5 m at intervals of 100 m. Pressure data are obtained using 25 barometers placed at a height of 50cm at intervals of 50 m. The pressure ports are designed and loaded to the barometers to reduce the dynamic pressure associated with wind and turbulence. Sampling intervals for both wind and pressure measurements are 100 msec and the sampling are synchronized by the external trigger from data logging computer. In this presentation, the system overview and the measurement technique will be described.

Keywords: winter tornado, A Linear Array of Wind and Pressure Sensor

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Mesoscale fixed point weather observation architecture by Drone fleet

*Yuichi Yaguchi[1], Masayuki Itaha[4], Shuzo Nakano[3], Kazuhiko Yamagishi[2], Tatsuya Iyobe[5]

1. The University of Aizu, 2. e-Robotics Fukushima Co., Ltd., 3. East-Japan Accounting Center Co., Ltd., 4. Japan Environment Research Co., Ltd., 5. Iyobe Shoji Ltd.

To know the generation mechanism of low clouds in the troposphere, we need to place a weather sensor with a certain density in the space of the radius from 2 to 20 km and from 1000 to 2000 meters altitude as the mesoscale meteorological observations. Such the studies of meteorological observations such as Mesonets (Rezaul. MAHMOOD, et. al., 2017) in the United States, and also studied in Japan (Kazuo SAITO, 2012), measure the weather information from the ground and satellites as the mesoscale meteorological observations. For practically, this information is used as a high-precision weather forecast with simulation (Kazuo SAITO, 2016). However, SODAR and LIDAR used for observation from the ground have limitations on the degree to measure wind direction and wind power (Dimitrios V. KANELLOPOULOS, 2016, Yoshiki ITO, 2009). Radiosonde is possible to measure the wind direction and force, but it has also limitation to sense from 2000 to 10000 meters because it cannot be placed directly at a specific point and can only obtain point information in chronological order. Although observations using aircraft can obtain temperature and humidity, it is difficult to correctly obtain wind direction and force based on the moving speed of the aircraft and turbulence of air current caused by the aircraft itself. The satellite sensor is one of the strong tool for large-scale meteorological measurement, but the spatial resolution is about 1.5 km and it is very difficult to sense a small area (Ryosuke NIWA, 2009).

In this research, in order to solve these problems by direct measurement, we propose a technique to measure using unmanned aerial vehicles at the same time. Specifically, six-propellers multicopter, generally called a drone which can hover for about 30 minutes per one and has a wind resistance of 20 m/s is manufactured, and a portable weather observation device utilizing ultrasonic wave is installed here. This meteorological observation device calculates the wind direction and wind force by calculating biaxial wind force by using ultrasonic waves. In addition, we install atmospheric temperature, humidity and barometer on weather observation equipment, and store on the payload computer a drone a measurement that is equal to or higher than the radiosonde. This meteorological observation device is raised by a mast to a height that does not affect disturbance of draft airflow measured in advance and measures it. In addition, the data accumulated in the payload computer are organized at about once every second, and it is transmitted to the ground from the 920 MHz compact power-saving radio station based on the LoRa modulation method and it is possible to display in real time. We can sense weather information at a fixed point on the mesoscale by aggregating this data at the same time at multiple sites through the Internet. In addition, since multi-copiers are out of the category of light aircraft of the aeronautical law up to 25 kg weight, we can easily skip to the altitude prescribed by the aeronautical law at the present time. However, since the altitude aimed for this research is to fly at a height where the clouds can reach from 1000 m to 2000 m, it is necessary to negotiate with the Ministry of Land, Infrastructure and Transport and air traffic control in advance.

As an actual demonstration, it was verified whether the drone of a single machine can be raised to an altitude of 500 m, 1000 m, 1500 m, 2000 m, respectively, and real time measurement can be performed. In the experiment conducted between 6:30 and 7:00 in the morning on 20, 21, 22 December 2018, the wind speed on the ground was about 3 to 5 m/s, but at the altitude of 1500 m it was 13 m / s For the first time. In addition, we confirmed that such information is transmitted to the ground in real time and can be

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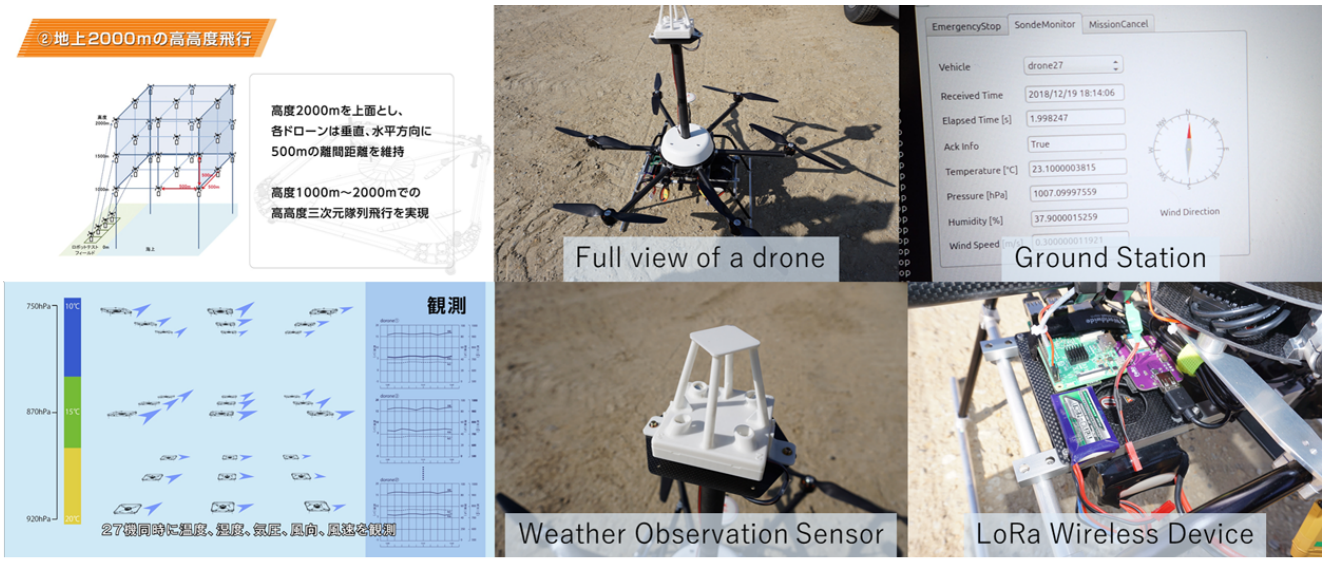
viewed directly. Moreover, using another drone equipped with the equivalent system, 27 drones flying into mesh type of 3 x 3 x 3 at intervals of 30 m in a space up to 100 m in height, verified to stay at the fixed point, succeeded doing. Using these combinations makes it possible to observe a fixed point in a wide area.

Keywords: Drone fleet, Simultaneous fixed point observation, Mesoscale weather observation



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Potential of dense weather event observation using surface optical fiber cable and DAS technology

*Tsunehisa KIMURA[1]

1. Schlumberger

Distributed acoustic sensing (DAS) technology is introduced in the oil and gas industry from around 2011 for monitoring pipelines and sensing intruders. In recent years, application of the latest optical fiber sensing technology using differential phase data called heterodyne distributed vibration sensing (hDVS) has made it possible to acquire the seismic data including the Vertical Seismic Profile (VSP)[1)]. Three-dimensional imaging can also be performed by a 3DVSP method[2)]. We have described the observation of natural earthquakes and waves, targeting the detection of tsunamis, using the hDVS device at recent JpGU and the seismological society of Japan (SSJ)[3)].

In September 2017, in cooperation with the Engineering Advancement Association of Japan (ENAA), we conducted a demonstration experiment of DAS technology including earthquake observation using optical fiber cable buried at depth of about 20 cm. Of the 400 m long optical fiber cables, 300 m was set back and forth in a 100 m long trench and the remaining 100 m was made to run along the ground surface, and then connected to a hDVS Tier-3 acquisition device. In other words, the optical fiber cable of about 50 m section that caused the ground to travel was under an environment susceptible to changes in weather. On the second day of the 4-day observation period, there was also a time zone in which rain fell and occasionally intense. Especially during the nighttime, continuous observation was carried out, so the fiber optic cable that crawled on the ground surface has not only accidental phenomena such as car traffic ground noise and natural earthquake, but also stationary phenomenon which seems to be the influence of rain fall was recorded. An example is shown in Fig 1.

This suggests that DAS technology using optical fiber as a vibration sensor may be used for weather observation. The hDVS/DAS records with GPS time stamp; the maximum observation length is depending on the type and state of fiber, but using low-loss single mode fiber a range of 40 km is achievable. If we can observe meteorological conditions over a range of tens of kilometers with a resolution of several tens of meters with a single device, we could issue more detailed warnings.

Installation of optical fiber for communication in Japan is often installed in the air such as utility pole and iron tower, except for the trunk communication network in the metropolitan area. Such optical fibers are directly influenced by rain and wind, however influence of noise sources generated on the surface such as vehicles, railways, factories, etc. is small. In other words, if you connect an hDVS/DAS device to an optical fiber on a transmission line called OPGW (optical fiber composite overhead ground wire), there is a possibility that weather network can be constructed in a short period of time. In the case of rain, when the rain is calm, the rate at which rain strikes the OPGW decreases, vibration or the dynamic strain of the optical fiber appears less, that is, the signal of hDVS/DAS is small. When the rain intensifies, the rate at which rain hits OPGW increases, vibration appears greatly, the signal of hDVS/DAS is large. So, it is possible to quantitatively observe local rainfall at intervals of several tens of meters. It would be possibly quantifying the size of rain drops as well as state of rain drops whether liquid or icy.

If rainfall and wind volume are large and change at the same time as a typhoon, it will be possible to take a method to separate each event. In the case of rain, raindrops collide with the fiber-optic cable, causing

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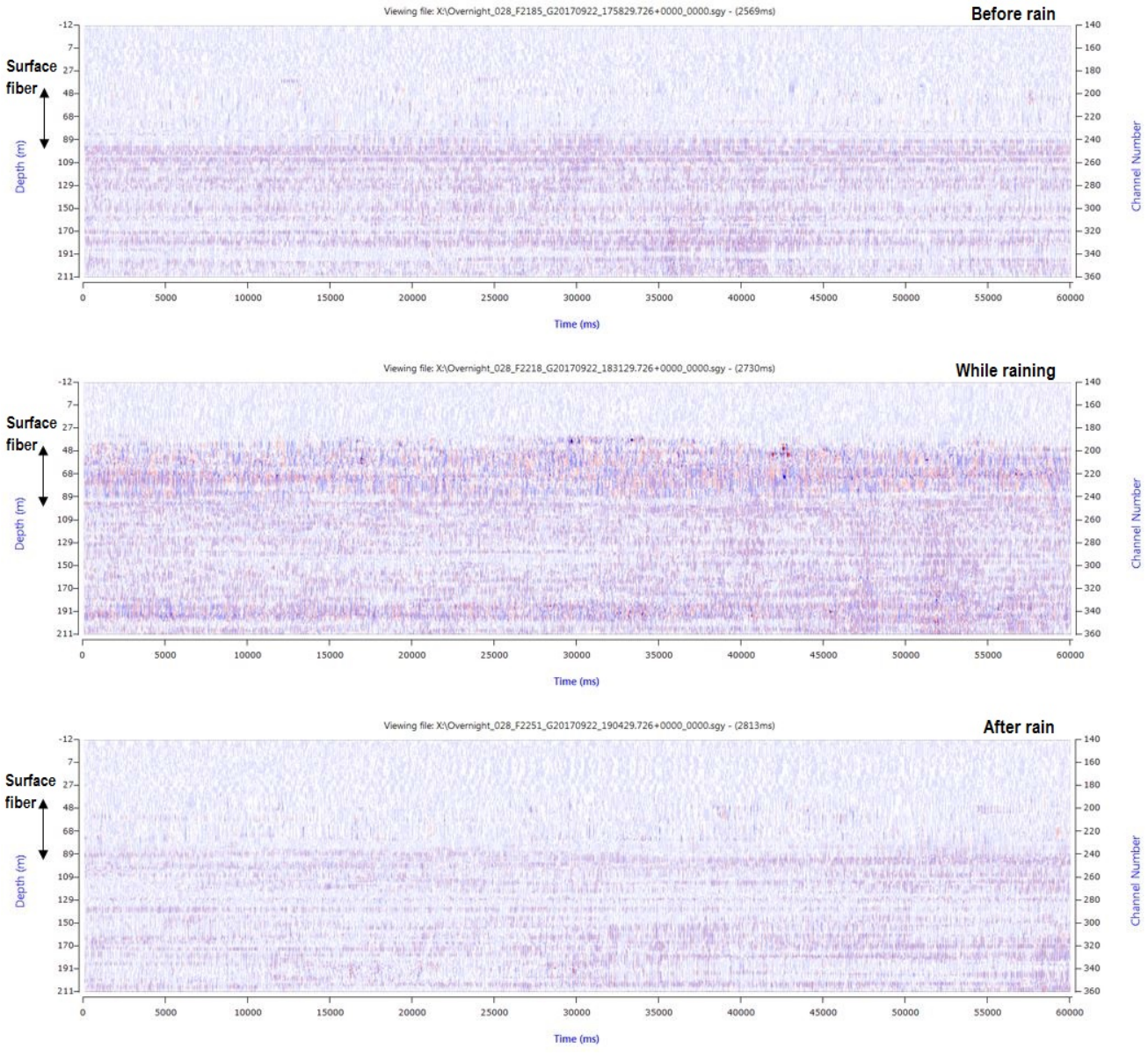
vibration, which is supposed to be more microscopic vibration and the frequency range of vibration is higher. On the other hand, in the case of wind, it seems that the frequency range is low due to macro vibration which affects the entire fiber optic cable between towers. When observing the ocean bottom earthquake using JAMSTEC owned submarine optical fiber cable, we observed the wave at the same time, but it is possible to separate two different events by changing the gauge length, which was presented at SSJ 2018[4]. Reprocessing the raw data for different gauge length is a capability that is unique to hDVS amongst the available DAS techniques. Real-time simultaneous observation of rainfall and wind will be possible by improving the hDVS system.

By connecting hDVS to underground, ocean floor, and terrestrial optical fiber networks, the possibility of constructing a comprehensive disaster prevention observation network of earthquakes, volcanoes, tsunamis, and observation of typhoons and Guerrilla rainstorm, has come to be seen.

Acknowledgements: We thank ENAA for permission to show recorded the hDVS data.

Keywords: DAS, hDVS, optical fiber, micro-scale meteorology, dense observation, typhoon



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Case study of environmental conditions and cloud microphysical properties of winter convective clouds developed in the Kanto plain

*Kentaro Araki[1], Shinsuke Satoh[2], Takuya Tajiri[1]

1. Meteorological Research Institute, 2. National Institute of Information and Communications Technology

In winter, convective clouds sometimes develop and cause local snowfalls and lightning strikes in the Kanto plain in Japan. To understand and forecast these winter convective clouds, detailed observations of environmental conditions and cloud microphysical properties are required. In this study, we performed a case study on the winter convective clouds on 26 January 2019, and examined the temporal variation of environmental conditions and properties of cloud and precipitation by using Japan Meteorological Agency (JMA) analysis data, dense surface meteorological observation data, Himawari-8 data, JMA operational radar data, photograph data of precipitation particles derived from citizen science, disdrometer and microwave radiometer data obtained at the Meteorological Research Institute in the Tsukuba, Ibaraki.

On 26 January, the surface pressure pattern was the winter monsoon type and the upper cold vortex moved to the northern Japan. Since the Kanto plain was located on the southeastern side of the cold vortex, synoptic condition was favorable for convection development in the Kanto plain. In respect of the mesoscale environments, the low-level convergence line was formed in the Kanto plain by west-northwesterly and northerly airflows that crossed the mountain areas. The Himawari-8 infrared images captured the cloud street associated with the convergence line from 13:30 JST (=UTC+9h), and radar echoes of convective clouds were observed by JMA Tokyo radar from 14:40 JST. Two convective clouds developed in the convergence line and passed over Tsukuba from about 15:30 to 16:30 JST. From the results of one-dimensional variational (1DVAR) analysis combined with numerical weather model and microwave radiometer data, it was found that thermodynamic environments significantly got unstable at 15 JST because of increases of low-level atmospheric temperature and influence of upper cold air flow.

Disdrometer in Tsukuba observed precipitation of two convective clouds from 15:34 to 15:44 JST and from 16:03 to 16:32 JST. Results of zenith-looking observation by micro rain radar showed the existence of echo at the altitude of 3-5 km 5-10 minutes before the surface precipitation at 15:34. Liquid water path (LWP) derived by the microwave radiometer significantly increased about 20 minutes before the surface precipitation by the first convective cloud, and the value of LWP in the case of second convective cloud was smaller than that of the first one. Results of disdrometer observation showed characteristics of the precipitation particles were similar to that of typical lump graupel, and fall velocity of the particles from the first convective cloud was significantly greater than that of second one. Photograph data by citizen science revealed that the graupel particles from the first convective cloud had densely rimed structures compared with those of second one. These differences of cloud microphysical properties would be due to the difference of the life stages of the convective clouds.

Keywords: convective clouds, snowfall, Kanto plain

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Numerical simulation of the urban effect on the atmospheric boundary layer structure in Tokyo using the SPUC urban canopy scheme

*Naoko Seino[1]

1. Meteorological Research Institute

Seino et al. (2018) investigated the influence of urbanization in the Tokyo area and showed that about one degree temperature rise in the central urban area in Tokyo can lead to 10% precipitation increase in August. We examined new method of the initial temperature field preparation in the model simulation, in which previously predicted temperatures of urban canopy elements were used as their initial temperatures in the succeeding simulation. Simulation results for one month in summer showed that the implementation of this forecast-cycle procedure improved the surface air temperature representation. On the other hand, comparisons with the winter observation results indicated that the atmospheric boundary layer height was underestimated in the model results. We will validate the model performance in other observation cases for the better understanding of finer scale features of urban effect.

Keywords: urbanization, numerical simulation , atmospheric boundary layer

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Surface layer model for instantaneous wind speeds designed by deep learning

*Junshi Ito[1,2], Hideaki Mouri[2]

1. Atmosphere and Ocean Research Institute, The University of Tokyo , 2. Meteorological Research Institute

parameterizations consider the Monin-Obukhov similarity law for diagnosing momentum transports between the lowest atmosphere and ground. This law was found in the relations between temporally averaged (typically periods of 10 minutes) wind speeds and momentum fluxes. We have suggested that it is inappropriate to apply the law for the parameterization in large eddy simulations in which turbulence fluctuation is involved in resolved wind speed at each grid point. However, we do not know a good alternative to the law.

In this study, we perform a preliminary attempt to apply the deep learning technique for the parameterization. Results of wind tunnel experiments are used for the date to be learned: the relationship between wind speeds and momentums fluxes in a short time scale (1 second, typically) was obtained in the condition with steady external winds and neutral stratification over ten hours.

Nine-tenth of the wind tunnel data for three kinds of different external wind speeds was inputted to the routine of the TensorFlow library. Then the validation is performed by the left of the data. The result shows that diagnoses of the momentum fluxes through the trained network show far better performances than those of the misused Monin-Obukhov law.

If the wind speed is inputted in training, the network overfits the other wind speed that has not been used for the training. It would be better to consider normalize wind speeds for the training to apply a wide range of wind speeds.

Keywords: Surface layer, Deep learning, Surface flux, Monin-Obkuhov law, Law-of-the-wall

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 303 3F

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo)

The interdisciplinary study on ocean diapycnal mixing and its impacts (Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem (OMIX) 2015-2020) is opening the integrated sciences from physical, chemical, biological oceanography to climate and fisheries sciences. In this section, results during the four years of OMIX projects and other related presentations are all welcome to be summarized and to facilitate plans of next projects.

9:00 AM - 9:10 AM JST | 12:00 AM - 12:10 AM UTC

Introduction

9:10 AM - 9:30 AM JST | 12:10 AM - 12:30 AM UTC

[AOS09-01] **Model Spectra for Turbulence Below and Above the Ozmidov Wavenumber**

★Invited Papers

*Eric L Kunze[1] (1.NorthWest Research Associates Redmond)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[AOS09-02] **A new parameterization of turbulent mixing caused by tidal flow over abyssal rough bathymetry**

*Toshiyuki Hibiya[1] (1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[AOS09-03] Development of CTD-attached microstructure measurements and basin-scale turbulence distribution in the North Pacific

*Ichiro Yasuda[1], Yasutaka Goto[2], Maki Nagasawa[1], Koenjong Lee[1], Toshiya Nakano[2], Shinya Kouketsu[3] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Meterolorogical Agency, 3.Japan Agency of Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[AOS09-04] The deep Pacific meridional overturning circulation simulated by a low-resolution ocean model

★Invited Papers

*Takao Kawasaki[1], Hiroyasu Hasumi[1] (1.Atmosphere and Ocean Research Insitutute, the University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[AOS09-05] The Role of Mixing and Geothermal Heating in Altering AABW and NADW Pathways

★Invited Papers

*Qianjiang Xing[1], Stephanie Downes[1], Kate Snow[2] (1.IMAS, Univ of Tasmania, AU, 2.School of GeoSciences, Univ of Edinburgh, UK)

Model Spectra for Turbulence Below and Above the Ozmidov Wavenumber

*Eric L Kunze[1]

1. NorthWest Research Associates Redmond

A model spectrum is constructed to describe both anisotropic stratified turbulence below and isotropic turbulence above the Ozmidov wavenumber using dimensional and dynamical scaling in terms of a cascade (or dissipation) rate ε, Coriolis frequency f, buoyancy frequency N and horizontal wavenumber k. The Ozmidov wavenumber $(N^3/\varepsilon)^{1/2}$ is the lowest wavenumber for which turbulence can overcome stratification to produce density overturns. The model reproduces observed spectral shapes and behavior in ocean and atmosphere measurements, specifically the −1 vertical wavenumber spectral slope in the invariant saturated spectrum band and +1/3 horizontal wavenumber spectral slope in the several decades immediately below the Ozmidov wavenumber. Aspect ratios become increasingly anisotropic below the Ozmidov wavenumber until reaching ~O(f/N). It is argued that geophysical turbulence can arise from anisotropic instability of the internal-wave field at wavenumbers well below the Ozmidov then cascade energy forward into isotropic turbulence, in contrast to the conventional wisdom that isotropic turbulence arises directly from vertical instability injecting energy at or above the Ozmidov wavenumber. Thus, anisotropic and isotropic turbulence are manifestations of the same forward energy cascade to dissipation.

Keywords: turbulence, dissipation , cascade

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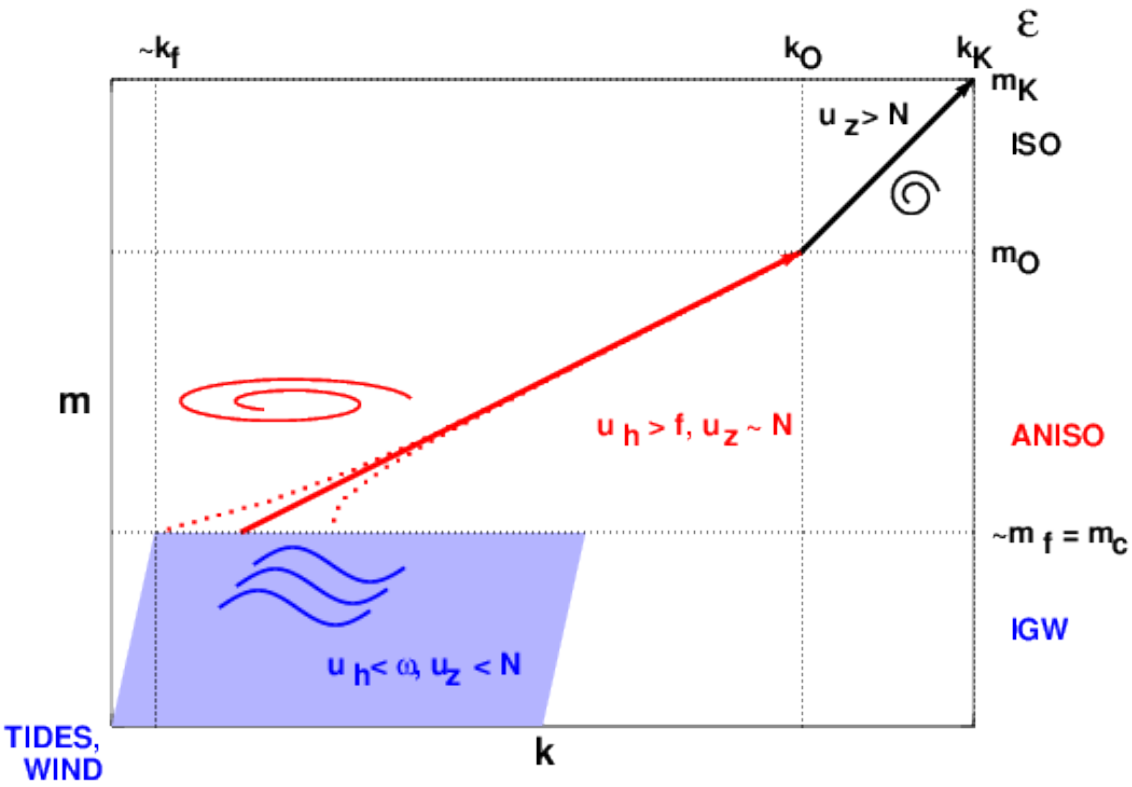

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A new parameterization of turbulent mixing caused by tidal flow over abyssal rough bathymetry

*Toshiyuki Hibiya[1]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

It is believed that tidal interaction with abyssal rough bathymetry can create mixing hotspots extending upward from the ocean bottom. Although there exist parameterizations of bottom-enhanced tidal mixing, they do not take into account that the internal waves generated by tide-topography interactions transform from *internal tidal waves* to *quasi-steady internal lee waves* as $k_H U_0 / \omega$ increases and exceeds unity (k_H is the horizontal wavenumber of the bottom topography; U_0 is the amplitude of the tidal flow; ω is the tidal frequency) (Mohri et al., 2010).

In this study, we formulate a new parameterization of tidal mixing over abyssal rough bathymetry in which the vertical decay scale of the energy dissipation rate (ε) is estimated by multiplying the theoretically obtained vertical group velocity of the *internal tidal wave* or the *quasi-steady internal lee wave* by the time scale of its nonlinear interaction (induced diffusion) with the background Garrett-Munk (GM) internal wave field (McComas and Müller, 1981). The resulting parameterization explicitly shows that the vertical decay scale of ε becomes independent of U_0 but inversely proportional to k_H squared when $k_H U_0 / \omega < 1$ and independent of k_H but proportional to U_0 squared when $k_H U_0 / \omega > 1$.

It is confirmed that the formulated parameterization predicts the vertical distribution of ε in agreement with that obtained from the eikonal calculation for the *internal tidal wave* or the *quasi-steady internal lee wave* propagating from the ocean bottom up into the background GM internal wave field (Iwamae et al., 2009; Hibiya et al., 2017).

Keywords: Tidal mixing, Abyssal rough bathymetry, Parameterization, Internal tidal waves, Internal lee waves, Resonant triad interactions

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Development of CTD-attached microstructure measurements and basin-scale turbulence distribution in the North Pacific

*Ichiro Yasuda[1], Yasutaka Goto[2], Maki Nagasawa[1], Koenjong Lee[1], Toshiya Nakano[2], Shinya Kouketsu[3]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Japan Meterolorogical Agency, 3. Japan Agency of Marine-Earth Science and Technology

A new efficient microstructure measurement with fast-response thermistors attached to CTD as common ship-based observational platforms were elaborated. This revealed cross-Pacific top-bottom turbulence distributions. Vertical distribution of turbulent energy dissipation is found to be proportional with local squared buoyancy frequency N^2(representing density vertical gradient) and local internal tide energy generation and dissipation, indicating that main part of energy dissipation of tide-induced turbulence occurs in the main thermocline. These contribute to revising models of tide-induced three-dimensional distribution used in ocean/climate models, which will contribute to reproducing ocean meridional overturning circulation and oceanic heat/material circulation.

Keywords: Turbulence, microstructure observation method, Meridional Overturning Circulation , Tide-induced mixing, North Pacific

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The deep Pacific meridional overturning circulation simulated by a low-resolution ocean model

*Takao Kawasaki[1], Hiroyasu Hasumi[1]

1. Atmosphere and Ocean Research Insitutute, the University of Tokyo

The deep Pacific meridional overturning circulation (PMOC) is composed by the northward transport of deep water originated from the Southern Ocean and upwelling of deep water. Tidal mixing is an important process for maintenance of the upwelling of deep water. Several previous modeling studies suggested that geothermal heating at the sea floor also has a significant impact on the strength of deep PMOC. Many previous modeling studies employed distributions of the tidal mixing enhanced near the ocean bottom (local mixing). A previous modeling study suggested that tidally-induced mixing far from the ocean bottom (remote mixing) significantly influences the strength and structure of PMOC. It is pointed out that the mixing energy depends on the ocean stratification by microscale vertical temperature profiles. In this study, we try to reproduce the PMOC by using the distribution of remote mixing based on the recent observation and geothermal heating.

The model employed in this study is an ocean general circulation model (COCO). Its horizontal grid size is 1 degree (non-eddy-resolving model). The horizontal distributions of local and remote tidal mixing energies are estimated by a tide model. The local mixing energy is enhanced near the bottom and decayed with height. The vertical profile of remote mixing depends on the ocean stratification, which is suggested by many observational and theoretical studies. The heating of bottom water is added based on the horizontal map of geothermal heating.
The strength of deep PMOC is increased by using the stratification-dependent tidal energy of the remote mixing. The geothermal heating also significantly enhances the deep PMOC. The northward volume transport of deep water originated from the Southern Ocean is smaller than an observational estimate by the one-time 17-month moorings. We additionally calculated the isotope ratio of radiocarbon (seawater age) for validation of the strength of the modeled PMOC. When both remote mixing and geothermal heating are applied, the age of seawater in the deep Pacific Ocean is consistent with observation.

Keywords: Pacific meridional overturning circulation, ocean general circulation model, tidal mixing

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The Role of Mixing and Geothermal Heating in Altering AABW and NADW Pathways

*Qianjiang Xing[1], Stephanie Downes[1], Kate Snow[2]

1. IMAS, Univ of Tasmania, AU, 2. School of GeoSciences, Univ of Edinburgh, UK

Antarctic Bottom Water (AABW) and North Atlantic Deep Water (NADW) constitute the deep Meridional Overturning Circulation (MOC). Surface mechanisms such as wind forcing, heat and freshwater fluxes have been identified as drivers of the deep-water mass formation. However, the interior drivers help transport NADW and AABW across ocean basins. Using sensitivity experiments in an Atlantic sector model, we diagnosed the influence of two poorly understood interior drivers on AABW and NADW, namely geothermal heating and vertical mixing, both as individual drivers and combined. We found that both enhanced mixing and geothermal heating increased the temperature and decreased the density of AABW and NADW. The meridional overturning circulation of NADW changed minimally (less than 3%) in all perturbations, while enhanced mixing and geothermal heating individually strengthened the AABW cell by 31.6% and 26.3%, respectively. The combined effect of the two mechanisms prompted a decrease in the MOC of the AABW cell by 21.1%. A diagnostic of Water Mass Transformation was applied to quantify the all transformations between water masses over time. The total transformation between AABW and NADW in the perturbations were estimated to be strengthened in the Atlantic sector model due to enhanced mixing and geothermal heating except a weakening water mass transformation from NADW into AABW posed by mixing and geothermal heating combined effect in the basin of south of 30S. The largest water mass transformation changes occurred in the Southern Ocean, where deep ocean property changes were remarkable throughout the water column.

Keywords: Mixing, Geothermal Heating, MOC, Water Mass Transformation

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 303 3F

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Jun Nishioka(Institute of low temperature science, Hokkaido University)

The interdisciplinary study on ocean diapycnal mixing and its impacts (Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem (OMIX) 2015-2020) is opening the integrated sciences from physical, chemical, biological oceanography to climate and fisheries sciences. In this section, results during the four years of OMIX projects and other related presentations are all welcome to be summarized and to facilitate plans of next projects.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[AOS09-06] Longterm changes in heat content, salinity and stratification over the Pacific Arctic and Subarctic continental shelves

★Invited Papers

*Seth L Danielson[1] (1.University of Alaska Fairbanks)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[AOS09-07] Important roles of marginal seas and intermediate water for micro- and macro-nutrients circulation in the North Pacific

*Jun Nishioka[1], Hajime Obata[2], Hiroshi Ogawa[2], Ichiro Yasuda[2] (1.Hokkaido University, Institute of low temperature sciences, 2.The University of Tokyo, Atmosphere and Ocean research institute)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[AOS09-08] An insight into chemical speciation of dissolved iron in the intermediate water of the North Pacific

*Youhei Yamashita[1], Jun Nishioka[2], Hajime Obata[3], Hiroshi Ogawa[3] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Institute of Low Temperature Science, Hokkaido University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[AOS09-09] Change in lower trophic level ecosystem and its complex mechanism in the North Pacific

★Invited Papers

Naomi Harada[1], Fujiki Tetsuichi[1], *Maki Noguchi Aita[1], Makio Honda[1], Minoru Kitamura[1], Takuhei Shiozaki[1], Yoshihisa Mino[3], Akira Kuwata[2], Kazuaki Tadokoro[2], Osamu Seki[4], Megumi Chikamoto[5] (1.Japan Agency for Marine-Earth Science and Technology, 2.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3.Institute for Space-Earth Environmental Research, Nagoya University, 4.Institute of Low Temperature Science, Hokkaido University, 5.International Pacific Research Center, University of Hawaii at Manoa)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[AOS09-10] Numerical simulation of iron cycle in the North Pacific

*Kazuhiro Misumi[1], Jun Nishioka[2], Hajime Obata[3], Daisuke Tsumune[1], Tsubono Takaki[1], Matthew C Long[4], Keith Lindsay[4], J. Keith Moore[5] (1.Environmental Science Research Laboratory, Central Research Institute of Electric Power Industry, 2.Institute of Low Temperature Science, Hokkaido University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Climate and Global Dynamics Laboratory, National Center for Atmospheric Research, 5.Department of Earth System Science, University of California at Irvine)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[AOS09-11] Influence of tide on the growth and migration of walleye pollock (*Gadus chalcogrammus*) in the Oyashio region

*Shin-ichi Ito[1], Zi-jian Wang[1], Hatsumi Nishikawa[3], Humio Mitsudera[3], Mitsuhiro Ishino[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Fisheries Research and Education Agency Japan, 3. Hokkaido University)

Longterm changes in heat content, salinity and stratification over the Pacific Arctic and Subarctic continental shelves

*Seth L Danielson[1]

1. University of Alaska Fairbanks

The recent century of increasing North Pacific marine temperatures culminated with a still ongoing multi-year marine heat wave over the Bering and Chukchi continental shelves. Relative to the modern observational record, 2014-2018 is characterized by anomalously elevated heat contents and temperatures, advanced spring sea ice retreat, delayed winter sea ice onset, and shifts in the timing and location of sea ice melt. To provide oceanic context to the satellite-derived sea ice concentration record, we construct a simple heat budget for the Chukchi shelf using atmospheric reanalysis model estimates of ocean-air heat fluxes (ECMWF ERA-Interim), lateral advection northward into the Arctic through Bering Strait, and in situ hydrographic profiles. We construct a new CTD climatology for the region, using a compilation of over 10^5 hydrographic profiles collected between 1950 and the present. Sea surface temperature analysis shows that 2014 was a transition year into a series of consecutive years for which the mean surface temperature exceeds 2 standard deviations from the longterm mean. Subsurface temperatures also exhibit steadily increasing temperatures over 2014 to 2018. Relative to 1979 to 2013, the most recent five years exhibits an acceleration of the Chukchi shelf heat engine: absorbing more incoming solar radiation in the spring and losing more latent and sensible heat to the atmosphere in the fall. On an annual basis the Chukchi shelf’ s rate of heat loss has modestly increased, but the Bering shelf is losing less heat to the atmosphere on an annual basis. However, the modeled heat flux changes are not temporally uniform over the course of the year and the anomalies exhibit spatial structure that is closely linked to the location of the sea ice cover. Our estimates suggest that the delivery of Pacific origin heat to the Arctic basin has appreciably increased in recent years. The analyses highlight the importance of the oceanic heat capacity, the heat loss rates of the cooling fall and winter, ice thickness, and tightly coupled positive feedbacks in heat exchanges between the ocean, ice and atmosphere. Understanding the new hydrograhic status quo is important for anticipating future physical and biological conditions on the Bering-Chukchi shelves. To the extent that ecosystem structure may be disrupted by altered seasonality, specie distributions, metabolic rates, and trophic exchange transfer efficiencies, we can use this work to better understand how the changing thermal environment may trigger a cascade of nonlinear reactions by the region’ s sympagic, pelagic and benthic communities.

Keywords: Ocean-atmosphere-ice heat fluxes, Bering-Chukchi shelf

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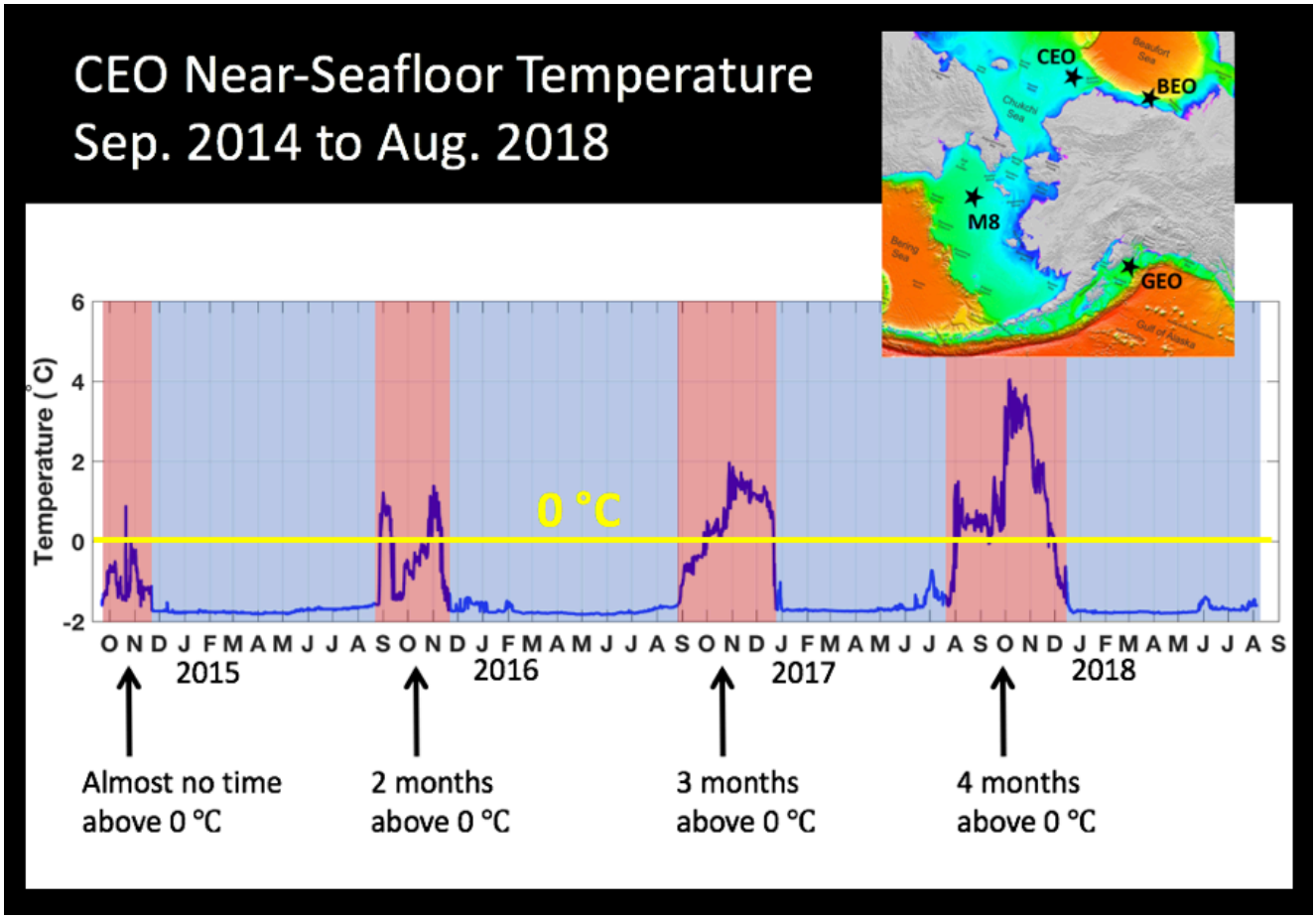

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Important roles of marginal seas and intermediate water for micro- and macro-nutrients circulation in the North Pacific

*Jun Nishioka[1], Hajime Obata[2], Hiroshi Ogawa[2], Ichiro Yasuda[2]

1. Hokkaido University, Institute of low temperature sciences, 2. The University of Tokyo, Atmosphere and Ocean research institute

The North Pacific is recognized as an end of the deep ocean conveyor belt circulation, and has been vaguely perceived as a place where deep high nutrient water rises to the surface. Details of the mechanism by which macro-nutrients are supplied from the deep layer to the surface layer, however, have not been properly described. Additionally, basin-scale micro-nutrient (iron) supply process for controlling biological production in this high nutrient region is still not completely understood. Here we report basin scale micro- and macro-nutrients circulation in the North Pacific. We compiled observed dissolved iron and nutrients dataset with other water properties in the North Pacific, as well as in the marginal seas and around the island chains. Judging from the isopycnal analysis of the dataset, a zonal gradient of dissolved iron concentration in the subarctic Pacific is constructed by iron rich water propagating from the Okhotsk Sea intermediate waters to the wide area of the upper-intermediate waters on the western North Pacific. While, high macro-nutrient water is discharged from the Bering Sea and spread in wide density range of the intermediate layer of the whole subarctic area. Two to three orders higher upward turbulent fluxes of the macro-nutrients were observed around the marginal sea islands chains, indicating that a part of macro-nutrients are supplied to surface and are returned and pooled to the intermediate layer through the biological production and microbial degradation of organic substances. These results highlighted an important roles of the marginal seas and the intermediate water for circulating micro- and macro-nutrients at the end of ocean conveyor belt.

Keywords: micro- and macro-nutrients circulation, marginal seas, North Pacific intermediate water

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An insight into chemical speciation of dissolved iron in the intermediate water of the North Pacific

*Youhei Yamashita[1], Jun Nishioka[2], Hajime Obata[3], Hiroshi Ogawa[3]

1. Faculty of Environmental Earth Science, Hokkaido University, 2. Institute of Low Temperature Science, Hokkaido University, 3. Atmosphere and Ocean Research Institute, The University of Tokyo

Iron has known to be one of the important factors controlling phytoplankton growth and nitrogen fixation by diazotrophs in large areas of the open ocean. Iron is less soluble in oxic seawater, therefore, external inputs of iron, which are spatially and/or temporally sporadic, regulate ocean primary productivity. The stability of iron in seawater, which is mainly controlled by organic ligands, is a contributing factor to its long-distance transport from external point sources to remote areas. Siderophores, saccharides, and humic substances have been considered to be probable iron-binding organic ligands in marine environments. Among these, bio-refractory humic substances can be the more important iron carriers in the intermediate waters, because siderophores and saccharides have known to be easily degradable by microbes.

Although sedimentary iron from continental margins has been considered to have a strong impact on iron distribution in the open ocean. In the North Pacific, it has been pointed out that sedimentary iron from the shelf region of the Sea of Okhotsk is widely distributed via circulation of the dense shelf water, the Okhotsk Sea Intermediate Water, the North Pacific Intermediate Water. However, the chemical species of iron contributing long-distance transport by the circulation of intermediate waters have not been clarified.

We determined a transect of concentration of dissolved iron together with levels of humic-like fluorescent dissolved organic matter, as a tracer of iron species, from the Sea of Okhotsk to the subtropical gyre of the western North Pacific. In this presentation, we will discuss possible chemical species of dissolved iron contributing to long-distance transport through the circulation of intermediate waters in the North Pacific.

Keywords: North Pacific, Iron, humid-like fluorescent dissolved organic matter

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Change in lower trophic level ecosystem and its complex mechanism in the North Pacific

Naomi Harada[1], Fujiki Tetsuichi[1], *Maki Noguchi Aita[1], Makio Honda[1], Minoru Kitamura[1], Takuhei Shiozaki[1], Yoshihisa Mino[3], Akira Kuwata[2], Kazuaki Tadokoro[2], Osamu Seki[4], Megumi Chikamoto[5]

1. Japan Agency for Marine-Earth Science and Technology, 2. Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 3. Institute for Space-Earth Environmental Research, Nagoya University, 4. Institute of Low Temperature Science, Hokkaido University, 5. International Pacific Research Center, University of Hawaii at Manoa

The principal aims of this study is to understand how primary and secondary producers response on the several potential nutrient supply processes associated with physical mechanisms such as atmospheric dynamics, vertical mixing and ocean current in the western North Pacific where is the most active biological drawdown area of sea surface pCO_2 in the world. Here we present the latest three results:

1) Mechanism of spring bloom of major phytoplankton, diatoms in the Oyashio region

The pelagic Oyashio region, western North Pacific is one of the world’s richest fishing ground. Massive diatom blooms occur extensively every spring in this region, suggesting that these blooms could support high biological productivity in this region. For spring blooming of diatoms in this region, two processes; supply of sufficient nutrients (including N, P, Si and Fe) and seeding of active diatom cells have been recognized to be essential. We have elucidated mechanism of the spring diatom blooms in the Oyashio region, focusing on seeding and growth processes of blooming diatoms. We examined conditions of spring diatom blooms and population dynamics of key diatom species in this area by analysis of long-term monitoring data of physico-chemical parmaters and diatom communities along a transect known as the “A-line” in the Oyashio off the southeast coast of Hokkaido, Japan.

2) Seasonal variation in eukaryotic phytoplankton from surface to the abyssopelagic zone

Eukaryotic phytoplankton is also important primary producer. Recent molecular techniques have revealed highly diverse species, but little is known about their dynamics. We examined size-fractionated eukaryotic phytoplankton communities by a 18S rRNA gene sequencing analysis from surface to abyssopelagic zone throughout one year at St. S1 (30°N, 145°E). The spring bloom was triggered not only by autochtonous community but also by phytoplankton delivered from outside regions. The allochthonous phytoplankton included many coastal origin taxa, and would significantly contribute to the biological pump at St.S1. Furthermore, our results show the taxa which efficiently export to deep waters in addition to well-known taxa having the “ballasting effect” such as coccolithophores and diatoms. Of particular interest is Prasinophytes putative *Pseudoscourfieldia marina*, *Ostreococcus*, *Micromonas*, and *Bathycoccus*, which sank to the abyssopelagic zone when they bloomed. Our molecular survey unveiled that the previously-overlooked species would significantly contribute to the subtropical biogeochemical cycles.

3) Sinking velocities of particles in the subarctic and subtropical regions of the western North Pacific Organic compounds produced by phytoplankton bloom settle into deeper layer as sinking particles. We have investigated the sinking velocities of particles to understand how biogeochemical cycle works after the production in the surface. Sinking particles were collected by drifting sediment traps at 100-200 m at

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two observation sites K2 (47°N, 160°E) and S1 and were fractionated in 5 ranges of sinking velocities between 5 and 1000 m d^{-1} using an elutriation system. The averaged sinking velocities (w_{POC}) calculated from the velocity distributions of POC were faster at S1. For S1 particles, a positive correlation was found between w_{POC} and $CaCO_3$ content. This indicates that particles containing large amounts of denser $CaCO_3$ sink faster than those containing large amounts of organic matter with low densities. Particles at K2, mainly composed of opal and organic matter, did not exhibit a clear relationship between w_{POC} and the denser opal. Instead, w_{POC} had a positive correlation with $\delta^{15}N$ of the sinking particles and was small (large) when the surface layer was stratified (well-mixed). These results implied that the upper water stability/mixing would influence the growth/fragmentation of aggregates as well as chemical composition of them, thereby affecting w_{POC}.

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Numerical simulation of iron cycle in the North Pacific

*Kazuhiro Misumi[1], Jun Nishioka[2], Hajime Obata[3], Daisuke Tsumune[1], Tsubono Takaki[1], Matthew C Long[4], Keith Lindsay[4], J. Keith Moore[5]

1. Environmental Science Research Laboratory, Central Research Institute of Electric Power Industry, 2. Institute of Low Temperature Science, Hokkaido University, 3. Atmosphere and Ocean Research Institute, The University of Tokyo, 4. Climate and Global Dynamics Laboratory, National Center for Atmospheric Research, 5. Department of Earth System Science, University of California at Irvine

Iron is an essential micronutrient for the marine phytoplankton growth. The deficiency of iron limits the primary productivity in the subarctic North Pacific, and also controls the production of nitrogen fixers in the subtropical region. Therefore, the understanding of iron cycle is key to understand biogeochemical cycling in the whole North Pacific. In this study, we used a regional ocean model (ROMS) coupled with a marine biogeochemical cycle model (BEC) configured to a quarter degree horizontal resolution to investigate iron cycle in the North Pacific. The model showed that iron supplied from shelf sediments are extensively distributed through the intermediate layer, and the transport is supported by adsorption/aggregation to and desorption/disaggregation from slowly sinking particles that prolongs residence time of iron in seawater. It is suggested that the iron supplied from shelf sediments of the Okhotsk and Bering Seas are exported to the Pacific Ocean, implying the biogeochemical linkage between the marginal seas and the ocean basin. Iron distributed in the intermediate layer is supplied to the surface water through diapycnal mixing around the Straits connecting the marginal seas. We will present the importance of the diapycnal mixing on primary productivity in the western subarctic region from the results of iron budget analysis.

Keywords: North Pacific, Iron, Nutrients

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Influence of tide on the growth and migration of walleye pollock (*Gadus chalcogrammus*) in the Oyashio region

*Shin-ichi Ito[1], Zi-jian Wang[1], Hatsumi Nishikawa[3], Humio Mitsudera[3], Mitsuhiro Ishino[2]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. Fisheries Research and Education Agency Japan, 3. Hokkaido University

A bioenergetics model of walleye pollock (*Gadus chalcogrammus*) coupled with a lower trophic level nutrient-phytoplankton-zooplankton model was developed to investigate environmental effects on the pollock growth in the Oyashio region. The bioenegertics model was coupled to was coupled to a migration model of pollock based on the environments calculated by an ocean general circulation model (CCSR (Center for Climate System Research) Ocean Component Model: COCO) coupled to a simple nutrient cycle model. In the growth-migration model, two physical environment conditions (with and without tidal forcing) were applied to investigate the tidal effects on the growth and migration of pollock. With tidal effect, warm water supply through the Tsugaru Strait to the southwestern coast of Hokkaido increased and a strong temperature front was formed along the southwestern coast of Hokkaido. Coastal current associated with the temperature front advected the pollock larvae to the Cape Erimo and pollock successfully settled to the bottom layer. Comparing the result without tidal forcing, tide potentially provide optimal temperature condition for growth and higher possibility to settle near coast. On the contrary, tide potentially provide lower nutrient supply with increasing nutrient poor water through the Tsugaru Strait. Therefore, the pollock growth itself did not change between with and without tidal forcing.

Keywords: marine ecosystem model, fish growth-migration model, walleye pollock

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[E] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 303 3F

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Shin-Ichi Ito(The University of Tokyo)

The interdisciplinary study on ocean diapycnal mixing and its impacts (Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem (OMIX) 2015-2020) is opening the integrated sciences from physical, chemical, biological oceanography to climate and fisheries sciences. In this section, results during the four years of OMIX projects and other related presentations are all welcome to be summarized and to facilitate plans of next projects.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[AOS09-12] What can horizontal stirring tell us about vertical mixing?

★Invited Papers

*Sylvia T Cole[1] (1.Woods Hole Oceanographic Institution)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[AOS09-13] Acoustic remote sensing of ocean mixing

★Invited Papers

*Tetjana Ross[1], Andone Lavery[2], Doris Leong[3], Rolf Lueck[4] (1.Institute Of Ocean Sciences, Fisheries and Oceans Canada, 2.Woods Hole Oceanographic Institution, 3.British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 4.Rockland Scientific International)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[AOS09-14] Assessment of the effectiveness of the global ocean state estimation using tide-induced mixing parameterizations

*Satoshi Osafune[1], Shuhei Masuda[1], Nozomi Sugiura[1], Doi Toshimasa[1], Tadashi Hemmi[1] (1.JAMSTEC)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[AOS09-15] **Energetics of Eddy-Mean Flow Interactions in Western Boundary Currents: The Kuroshio and the Gulf Stream**

★Invited Papers

*Enrique N Curchitser[1], Dujuan Kang[1], Xiaomei Yan[2] (1.Rutgers University New Brunswick, 2.Institute of Oceanology, Chinese Academy of Sciences)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[AOS09-16] Mixing Processes in the Kuroshio region and their influence on the low-trophic ecosystem

★Invited Papers

*Xinyu Guo[1], Takeshi Matsuno[2], Tomoharu Senju [2], Kaoru Ichikawa[2], Takahiro Endoh[2], Eisuke Tsutsumi[2], Ayako Nishina[3], Hirohiko Nakamura[3], JING ZHANG[4], Daisuke Hasegawa[5], Naoki Yoshie[1], Toru Kobari[3] (1.Center for Marine Environmental Studies, Ehime University, 2.Research Institute for Applied Mechanics, Kyushu University,, 3.Faculty of Fisheries, Kagoshima University, 4.Graduate School of Science and Engineering, University of Toyama, 5.Tohoko National Fisheries Research Institute)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[AOS09-17] Very strong turbulent mixing over 30-km and 200-m lateral and vertical scales in the Kuroshio near the continental slope in Hyuganada Sea

*Takeyoshi Nagai[1], Silvana Duran[2], Diego Otero[2], Yasutaka Mori[1], Naoki Yoshie[3], Kazuki Ohgi[3], Daisuke Hasegawa[4], Ayako Nishina[5], Toru Kobari[5] (1.Department of Ocean Sciences, Tokyo University of Marine

Science and Technology, 2.Facultad de Pesquería, Universidad Nacional Agraria La Molina, Peru, 3.Center for Marine Environmental Studies, Ehime University, 4.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 5.Faculty of Fisheries Kagoshima University)

What can horizontal stirring tell us about vertical mixing?

*Sylvia T Cole[1]

1. Woods Hole Oceanographic Institution

Basin-scale tracer distributions are influenced by horizontal stirring and eddy diffusivity. Eddy diffusivity estimated from Argo temperature and salinity profiles together with ECCO-2 eddy kinetic energy has been updated to include additional years of data, finer horizontal resolution, and a formal error estimate. Assumptions related to vertical mixing inherent in the method for estimating eddy diffusivity are tested. Near the surface, thermohaline structure is influenced by the atmosphere more so than either horizontal stirring or vertical mixing. Locally, vertical mixing is responsible for setting thermohaline structure where large-scale horizontal gradients are weak. The equatorial regions are particularly influenced by these imprints of vertical mixing. Implications for ocean dynamics and numerical modeling are discussed.

Keywords: Global Ocean, Mesoscale dynamics, Tracer distributions

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Acoustic remote sensing of ocean mixing

*Tetjana Ross[1], Andone Lavery[2], Doris Leong[3], Rolf Lueck[4]

1. Institute Of Ocean Sciences, Fisheries and Oceans Canada, 2. Woods Hole Oceanographic Institution, 3. British Columbia Ministry of Forests, Lands, Natural Resource Operations and Rural Development, 4. Rockland Scientific International

Based on data collected in a number of environments, from coastal fjords to the north Atlantic, from the laboratory to Antarctica, we present evidence for sound scattering from turbulent and double diffusive microstructure in the ocean. We discuss the advantages of using acoustics to observe ocean mixing (i.e. inexpensive, fast and remote). We also discuss the limitations (e.g. ambiguity in source of scattering) and some methods for dealing with it. We illustrate how one of these ambiguities can even be turned into a strength for observing zooplankton in turbulence, through the use of broadband acoustics.

Keywords: oceanic turbulence and mixing, underwater acoustics , ocean observation, bio-physical interactions

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Assessment of the effectiveness of the global ocean state estimation using tide-induced mixing parameterizations

*Satoshi Osafune[1], Shuhei Masuda[1], Nozomi Sugiura[1], Doi Toshimasa[1], Tadashi Hemmi[1]

1. JAMSTEC

Recent data synthesis experiments showed that adjusting mixing coefficients through data assimilation approach is a promising way to reduce a global misfit between a model simulation and ocean observations, while mixing coefficients should satisfy constraints from energetics. Aiming for a data synthesis experiment that is energetically consistent with the known constraint on the ocean energy budget and can assimilate turbulence observation data, we have developed a new quasi-global four-dimensional variational dataassimilation system using two parameterizations for tidally induced vertical mixing. As a preliminary preparation of the synthesis experiment, we optimally estimated their parameters along with other physical parameters based on the Green’ s function method. The simulation using the optimal parameters well reproduces temperature and salinity in the deep Pacific Ocean. Using this simulation as the first guess field, we are conducting a long-term data synthesis experiment. We will present some preliminary results of the synthesis experiment to assess the effectiveness of our new system.

Keywords: vertical mixing, tide, data assimilation

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Energetics of Eddy-Mean Flow Interactions in Western Boundary Currents: The Kuroshio and the Gulf Stream

*Enrique N Curchitser[1], Dujuan Kang[1], Xiaomei Yan[2]

1. Rutgers University New Brunswick, 2. Institute of Oceanology, Chinese Academy of Sciences

Mesoscale eddies are most energetic along Western Boundary Currents, such as the Gulf Stream in the North Atlantic and the Kuroshio in the North Pacific. A better understanding of the eddy dynamics and variability is essential for prediction of ocean states and evaluating the ocean contributions to the climate system and interactions with the ecosystem. We derive a full set of eddy energetics analysis framework that provides quantitative description of the energy sources, sinks, and exchanges among different energy reservoirs. We perform detailed energetics analysis of the Kuroshio eddies using the OFES quasi-global ocean simulation and compare it to high-resolution simulations of the Gulf Stream region. Through the combination of theoretical and numerical analysis, we investigate eddies' generation, spatio-temporal variability and the underlying dynamics in these two eddy-prominent Western Boundary Current regions.

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Mixing Processes in the Kuroshio region and their influence on the low-trophic ecosystem

*Xinyu Guo[1], Takeshi Matsuno[2], Tomoharu Senju [2], Kaoru Ichikawa[2], Takahiro Endoh[2], Eisuke Tsutsumi[2], Ayako Nishina[3], Hirohiko Nakamura[3], JING ZHANG[4], Daisuke Hasegawa[5], Naoki Yoshie[1], Toru Kobari[3]

1. Center for Marine Environmental Studies, Ehime University, 2. Research Institute for Applied Mechanics, Kyushu University,, 3. Faculty of Fisheries, Kagoshima University, 4. Graduate School of Science and Engineering, University of Toyama, 5. Tohoko National Fisheries Research Institute

In order to understand the vertical mixing processes in the Kuroshio, we carried out field observations in the Luzon Strait, east of Taiwan, outer shelf region of the East China Sea, and Tokara Strait in the past several years. The strong vertical mixing mainly due to interaction between the Kuroshio and seamounts were found in the areas east of Taiwan and Tokara Strait, while that mainly due to internal tides was found in the Luzon Strait and outer shelf region of the East China Sea. The nitrate flux associated with the strong vertical mixing in the Kuroshio was estimated using simultaneously measured nitrate concentration and vertical eddy diffusivity coefficient. The influences of vertically supplied nitrate on the phytoplankton and zooplankton were examined by field observations and laboratory experiments. In addition to the vertical mixing, the supply of nutrients from coastal waters was also observed and that due to horizontal and vertical advections were also diagnosed from results of a numerical model for a purpose of fully understanding on the nutrient dynamics along the Kuroshio.

Keywords: Kuroshio, Vertical Mixing, low-trophic ecosystem

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Very strong turbulent mixing over 30-km and 200-m lateral and vertical scales in the Kuroshio near the continental slope in Hyuganada Sea

*Takeyoshi Nagai[1], Silvana Duran[2], Diego Otero[2], Yasutaka Mori[1], Naoki Yoshie[3], Kazuki Ohgi[3], Daisuke Hasegawa[4], Ayako Nishina[5], Toru Kobari[5]

1. Department of Ocean Sciences, Tokyo University of Marine Science and Technology, 2. Facultad de Pesquería, Universidad Nacional Agraria La Molina, Peru, 3. Center for Marine Environmental Studies, Ehime University, 4. Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 5. Faculty of Fisheries Kagoshima University

The Kuroshio carries nutrients in its subsurface layer as a nutrient stream, which flows along the southern coast of Japan. The nutrients in the dark subsurface layers of the Kuroshio, however, are not available for phytoplankton unless they are supplied through diapycnal mixing processes and/or adiabatic upwelling to sunlit surface layers. It has been unclear whether and how these nutrients are supplied to euphotic zone on the continental shelves. In this study, using a state-of-the-art tow-yo microstructure profiler, it is shown that the very strong turbulence occurs over a scale of 30-km and 200-m along lateral and vertical direction, respectively, near the Kuroshio, which flows on the continental slope in Hyuganada Sea, southeast of Kyushu. The observed turbulent kinetic energy dissipation rates are O(10^{-7} Wkg^{-1}) near the Kuroshio over a distance of 30-km, which corresponds to O(10^{-3} m^2s^{-1}) of eddy diffusivity. Turbidity data suggest that this strong turbulence at the shelf edge provides sediment resuspension from the bottom to 50 m depth. Nitrate diffusive flux is estimated as large as 1-10 mmol N m^2day^{-1} at the base of euphotic zone.

Keywords: Kuroshio, Turbulence, Nutrients

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[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_7

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo)

The interdisciplinary study on ocean diapycnal mixing and its impacts (Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem (OMIX) 2015-2020) is opening the integrated sciences from physical, chemical, biological oceanography to climate and fisheries sciences. In this section, results during the four years of OMIX projects and other related presentations are all welcome to be summarized and to facilitate plans of next projects.

[AOS09-P01] Correction method of fast-response thermistors data to estimate turbulence intensity

*kimura shino[1], Yasutaka Goto[2], Koenjong Lee[1], Ichiro Yasuda[1] (1.The Univercity of Tokyo, 2.Meteorological Agency)

[AOS09-P02] Observation of turbulent mixing using a deep float with microstructure sensors

*Shuo Zhai[1], Ichiro Yasuda[1], Masaaki Kikuchi[1], Yasutaka Goto[1], Koenjong Lee[1], Takahiro Tanaka[2], Ken Yamaki[3], Yutaka Imamura[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Fisheries Research Agency, 3.TSK Tsurumi-Seiki Co., Ltd., 4.Aomori Prefectural Industrial Thechnology Research Center, Fisheries Research Insititute)

[AOS09-P03] Evaluation of the underwater glider flight model using the electromagnetic current sensor

*Takahiro Tanaka[1], Daisuke Hasegawa[1], Takeshi Okunishi[1], Ichiro Yasuda[2] (1.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 2.Atmosphere and Ocean Research Institute, University of Tokyo)

[AOS09-P04] Mixing processes observed by a slocum glider at the Oyashio-TWC front

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[AOS09-P05] Impact of the astronomical lunar 18.6-yr tidal cycle on El-Niño and Southern Oscillation

*Ichiro Yasuda[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P06] The effect of 18.6-year period lunar nodal cycle on Pacific Decadal Oscillation (PDO)

*Masaki Hamamoto[1], Ichiro Yasuda[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P07] A comparison of ocean deoxygenation between CMIP5 models and an observational dataset

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[AOS09-P08] Pacific Ocean State Estimation and Clarification of Mechanism of Ocean Circulation by Data Synthesis of Global Observations

*Shuhei Masuda[1] (1.Japan Agency for Marine-Earth Science and Technology)

[AOS09-P09] Impact of Tidal Vertical Mixing to Barotropic Water Exchange between the Sea of Okhotsk and Pacific through Diffusive Adjustment with Turbulent Closure Scheme

*Hung Wei Chou[1], Humio Mitsudera[1], Hatsumi Nishikawa[1], Kaihe Yamazaki[2] (1.Hokkaido University, Institute of Low Temperature Science, 2.Hokkaido University, Graduate School of Environmental Science)

[AOS09-P10] Distributions of organic Fe-binding ligands in the eastern and western subarctic North Pacific

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[AOS09-P11] Chemical and physical speciation of copper in the subarctic North Pacific

*Kuo Hong Wong[1], Hajime Obata[1], Taejin Kim[2], Yoshiko Kondo[3], Jun Nishioka[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Seoul National University, Korea, 3.Nagasaki University, 4.Institute of Low Temperature Science, Hokkaido University)

[AOS09-P12] Latitudinal and temporal variations in phytoplankton size structure within mesoscale eddies from space

*Hisatomo Waga[1], Toru Hirawake[1], Ueno Hiromichi[1] (1.Hokkaido University)

[AOS09-P13] Structure and impact of the Kuroshio nutrient stream

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[AOS09-P14] Enhanced nutrient supply and biogeochemical impacts induced by internal waves in the oligotrophic northern South China Sea

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[AOS09-P15] Mixing over the eastern ridge in the Luzon Strait caused by high-mode internal waves

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[AOS09-P16] **From the Luzon Strait to the Tsushima Strait: Water masses and nutrient transports approached using ^{137}Cs**

*Siteng Zhu[1], JING ZHANG[1], Shota Kambayashi[2], Takeshi Matsuno[3], Eisuke Tsutsumi[3], Shigenobu Takeda[4], Seiya Nagao[5], Hiroshi Inoue[5], Hiroshi Ogawa[6], Ichiro Yasuda[6] (1.University of Toyama,

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[AOS09-P17] Impact of cyclonic eddies and typhoons on biogeochemistry in the oligotrophic ocean based on time-series observation at the western Pacific subtropical station KEO

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[AOS09-P18] Island-mass effect on the phytoplankton and zooplankton community in south of Japan

*Kiyotaka Hidaka[1], Kazuaki Tadokoro[1], Hiroomi Miyamoto[1], Tadafumi Ichikawa[1] (1.Japan Fisheries Research and Education Agency)

[AOS09-P19] Influence of enhanced deep circulation due to geothermal heat on biogeochemical cycle in the Pacific Ocean

*Shogo Urakawa[1], Hideyuki Nakano[1], Hiroyuki Tsujino[1], Kei Sakamoto[1], Takahiro Toyoda[1], Goro Yamanaka[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

[AOS09-P20] The Parameterization of the Pressure-Strain Correlations in the Stably or Unstably Stratified Ocean Surface Layer.

*Yusuke Ushijima[1], Yutaka Yoshikawa[1] (1.Graduate School of Science, Kyoto University)

[AOS09-P21] Numerical studies on asymmetric responses of the upper ocean to tropical cyclone

*Daiki Okura[1], Yutaka Yoshikawa[1] (1.Graduate School of Science, Kyoto University)

[AOS09-P22] Influence of the distortion of the internal wave field on estimates of turbulent mixing using fine-scale parameterizations

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Correction method of fast-response thermistors data to estimate turbulence intensity

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Fast-response thermistors (FP07) can be used to estimate turbulent energy dissipation rate ε and temperature dissipation rate χ. However, correction is necessary because the insufficient response of FP07 causes underestimate for relatively strong turbulence and individual FP07 sensors have different response. In this study, using simultaneously observed shear probe and FP07 data from a free fall microstructure profiler descending at the speed of 0.6-0.7 m/s, ε_T from various FP07 are compered with ε_S from shear probe to estimate how much correction is necessary for FP07 data. For 3 (7) msec time constant of FP07 for double-pole (single-pole) correction, ε_T is consistent with ε_S within a factor of 3 in the range of ε_S =10^-10 ~10^-7 W/kg. In the presentation we also discuss the impact of correction on χ and the validity of ε_T under double diffusion.

Keywords: vertical mixing, turbulence

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Observation of turbulent mixing using a deep float with microstructure sensors

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Automated microstructure obsevation method using a deep float (DeepNINJA) with velocity shear probe and fast-response thermistor is being elaborated. From the field test observation in August 2016, availability of shear probe data was tested by comparing turbulent dissipation rates from thermistor. Shear probe data were found to be worse by vibration from motor operartions at buoyancy adjustment and by noise at slow ascending speed of the float. Vertical profiles of turbulent energy dissipation rate could be obtained with the hybrid use of shear probe and thermistor data by correcting time-constant of the termistor with reliable shear probe data and filling gaps of unavailable shear probe data. Data will be reported for the deep float which was deployed on December 12, 2018, in the western slope of Japan Trench off Aomori. The float is observing 0 - 4000 m turbulence profile every 10 days and will be recovered in April R/V Shinsei-maru cruise.

Keywords: vertical mixing , deep float, energy dissipation rate

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Evaluation of the underwater glider flight model using the electromagnetic current sensor

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Turbulence measurement by underwater gliders has become more common in recent years. For the accurate estimation of energy dissipation rates, the accurate measurement of the fall rate and gliding path angle is necessary. The gliding path angle should take the angle of attack (AOA) into account, which is the difference between the gliding path angle and the pitch angle. AOA calculation has been done by using the so-called flight model assuming dynamical force balance in the quasi-steady state. Due to the difficulty in measuring AOA directly, the validity of AOA derived from the flight model and the flight model itself has not been adequately evaluated so far. In this study, we put the electromagnetic current sensor (EM sensor) on the turbulence package to obtain AOA directly and to compare the AOA from EM sensor with that from the flight model. Using the dataset obtained by a Slocum glider in Jul. - Aug. 2017, we found that AOA from the EM sensor during descent and ascent has a mean (standard deviation) of 0.7 (1.2) deg. and -0.7 (1.1) deg., respectively, while AOA from the flight model is 4.9 (0.4) deg. and -4.5 (0.5) deg., respectively. In order to know what cause this difference, we discuss the validity of parameters given in the flight model. It is suggested that a drag coefficient due to parasite drag given in the flight model may be somewhat larger than that calculated using the EM sensor.

Keywords: underwater glider, flight model, electromagnetic current sensor, angle of attack

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Mixing processes observed by a slocum glider at the Oyashio-TWC front

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In order to grasp the detailed mixing processes along the frontal region between the Oyashio and the Tsugaru Warm Current (TWC), we conducted a zigzag survey crossing the front several times from the merging region of the two current systems to the down stream by an underwater glider (Slocum G2 Glider) equipped with a turbulence sensor, from July 24thto August 29thin 2017. The observed frontal structure indicated the subduction and the intrusion processes of the cold and fresh Oyashio water under the warm and salty TWC water, along layer between 26.5 to 26.8 sigma-theta, which resulted the favorable conditions to the salt finger convection at the upper interface along the 26.5 sigma-theta, and the diffusive convection at the lower interface along the 26.8 sigma-theta where the fresh and cold Oyashio water lying above the warm and salty water. The strong turbulence intensity is observed around the intruded layer, and the mean temperature and the salinity in the layer became warmer and saltier with the increase of the distance from the front, which suggested the time evolution of the vertical mixing driven by double diffusive convections between the three different water masses. Though the strongest turbulence intensity was observed around the frontal region, which may suggest the importance of the cabbeling effect as the additional source of the turbulent mixing.

Keywords: double diffusion, mixing, cabbeling

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Impact of the astronomical lunar 18.6-yr tidal cycle on El-Niño and Southern Oscillation

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Even though El-Niño and Southern Oscillation (ENSO) has a tremendous impact on global climate and society, its long-term forecast remains difficult. In this study, we discovered a statistically significant relationship between ENSO timing and the 18.6-year period lunar tidal cycle in the mature-phase (December –February) ENSO time-series during 1867–2015 and extending back to 1706 with proxy data. It was found that El-Niño tended to occur in the 1st, 10th, and 13th years after the maximum diurnal tide in the 18.6-yr cycle, and La-Niña tended to occur in the 3rd, 12th, and 16th years. These tendencies were also confirmed by corresponding sea-surface temperature (SST) and sea-level pressure (SLP) distributions; particularly Pacific SST and SLP spatial patterns in the third La-Niña and the tenth El-Niño year well resemble those of Pacific Decadal Oscillation (PDO). These findings contribute to understanding and forecasting long-term ENSO variability.

Keywords: El-Niño and Southern Oscillation, air-sea interaction, tide, mixing, climate

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The effect of 18.6-year period lunar nodal cycle on Pacific Decadal Oscillation (PDO)

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Pacific Decadal Oscillation (PDO) is the most dominant decadal-inter-decadal ocean-climate variability over the North Pacific; however, the periodicity and cause have not been fully understood. Previous studies suggested that 18.6-year period lunar tidal cycle ($T_{18.6}$) regulate bi-decadal PDO variability through changes in the strength of diapycnal mixing of ocean around the Kuril Islands to result in ocean variability, together with air-sea interactions in the mid-latitude North Pacific and/or equatorial Pacific. In the present study, 297yr-long reconstructed PDO timeseries was re-examined, and 27.9yr (3/2 times 18.6-yr, henceforth, $T_{27.9}$) period variability was significantly detected, and the zero-crossing from minus to plus was found to occur simultaneously with $T_{18.6}$ variability in the interval of 55.4 years (3 times $T_{18.6}$). In the PDO spectrum, a broad multi-decadal 50-80-yr peak (corresponding to 3-5 times $T_{18.6}$, henceforth T_M) was also detected with the zero-crossing synchronized with $T_{18.6}$; this is the extension of previous studies during 1900-2000 back to 1700s on the synchronous changes of bi-decadal and penta-decadal variabilities. These $T_{18.6}$, $T_{27.9}$ and T_M explain 71% of the 10-year low-passed PDO variability. These imply that the 27.9-yr and the multi-decadal variabilities could be related to $T_{18.6}$ tide-induced variability, and may be excited by $T_{18.6}$ tidal forcing, considering that external periodic forcing for delayed oscillator models could excite 3 times period of the external forcing and some non-linear processes may make the half-period variability.

Keywords: 18.6-year period lunar nodal cycle, Pacific Decadal Oscillation

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A comparison of ocean deoxygenation between CMIP5 models and an observational dataset

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Recent studies revealed that the ocean deoxygenation has been accelerating since the 1980s over the global oceans (Schmidtko et al. 2017; Ito et al. 2017), and the observed trend in the last half-century appears to be much larger than the model simulations conducted for CMIP5 (Bopp et al. 2013). This discrepancy is an important issue of the ocean deoxygenation researches as highlighted by a review paper published in the last year (Oschlies et al. 2018).

In order to understand better the relations of oxygen variations between CMIP5 models and observations, we compare oxygen concentration simulated by CMIP5 models and gridded oxygen anomaly dataset used by Ito et al. (2017). For the global oceans, the observed oxygen reduction rate for the historical experiment period appears to be within uncertainty of the models, though this result can be sensitive to the choice of the analysis period associated with the rapid recent oxygen reduction. We also closely examined the two basins that are relatively well sampled, i.e., the North Pacific and the North Atlantic. It is found that the observed North Pacific oxygen reduction is much stronger than the simulated ones, but such a strong reduction of observed oxygen does not occur in the North Atlantic. These results suggest that there are substantial spatio-temporal variations of oxygen concentration on decadal timescales and their mechanism in each basin should be explored in future studies.

Keywords: North Pacific, North Atlantic

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Pacific Ocean State Estimation and Clarification of Mechanism of Ocean Circulation by Data Synthesis of Global Observations

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Our aim is to synthesize pre-existing ocean data with newly-acquired turbulence data using state-of-art assimilation technique. Available observations of turbulence strength in the ocean, will be “blended” with pre-existing ocean data applying dynamically self-consistent state estimation approach with 4D-VAR adjoint system. We propose some new techniques and schemes to assimilate turbulence data, which tends to include unique features. The obtained state estimation will provide improved description of ocean circulation, its heat and salt transports, and oceanic ecosystem at lower trophic level.

Keywords: OMIX, ocean , mixing , data assimilation

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Impact of Tidal Vertical Mixing to Barotropic Water Exchange between the Sea of Okhotsk and Pacific through Diffusive Adjustment with Turbulent Closure Scheme

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The pattern of exchange flow between the Sea of Okhotsk and Pacific is a system composed by an Okhotsk-ward inflow through Kruzenshtern strait in north and a Pacific-ward outflow through Bussol strait in south. One of major theories for explaining the dynamic of water exchange through Kuril Island Chain is the turbulence induced by tidal vertical mixing. Turbulence is an important physical process in geostrophic boundary layer, and because of the complexity of topographic in Kuril island chain, the breaking of internal tides in island coast area leads to increase the thickness of surface mixing layer and causes tilting of isopycnal layer in vicinity. The tilting of isopycnal layer around islands forms a clockwise flow along the shore by geostrophic adjustment. However, above process is majorly broclinicly, and how can it impact to barotropic component is still unknown.

By setting the tidal force as a controlled variable, results from realistic OGCM model COCO show only the case with tidal forcing can consistent with the exchange flow pattern as historical observation (Fig.1). Besides, the vertical diffusivity values also show the magnitude difference in summer time, which the flow in north strait in non-tidal case is opposite to tidal one (Fig.2). Therefore, we designed four experiments for understanding the impact of tidal diffusive adjustment in summer: 1. install vertical diffusivity value generated by tidal case into non-tidal run; 2. install vertical diffusivity value generated by non-tidal case into tidal run; 3. set the vertical diffusivity value as zero in tidal case and 4. in non-tidal case as well. Further, for preventing the underestimates the depth of the mixing layer in Mellor-Yamada turbulence closure scheme, two more experiments with the larger vertical diffusivity mask are applied in both tidal and non-tidal case. After calculating the fraction of baroclinic and barotropic components in either north strait or southern strait, results show the vertical mixing dose influence the strength of volume transported but not the direction as original tidal and non-tidal case shows. Hence, for further understanding the impact of vertical diffusivity, we start a tidal forcing run with non-tidal initial conditions to detect the relationship between the flow direction and magnitiude of vertical diffusivity values by time developing. But the baroclinic result implies that the vertical mixing might not be the main reason to control the flow direction (Fig.3).

This study also implies the tidal impacts in OGCM is not only the vertical mixing, but other geostrophic fluid dynamics might occur, especially the interaction of topography with tidal waves. Therefore, for reproducing the real ocean phenomena, movement of tidal waves should be considered.

Keywords: OGCM, tidal mixing , Okhotsk, cross-basin exchange system

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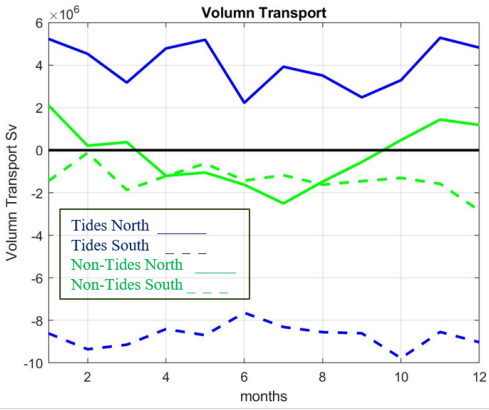

Fig.1: volume transportation in tidal and non-tidal run.
Positive value is Okhotsk-ward and negative value is Pacific-ward flow.

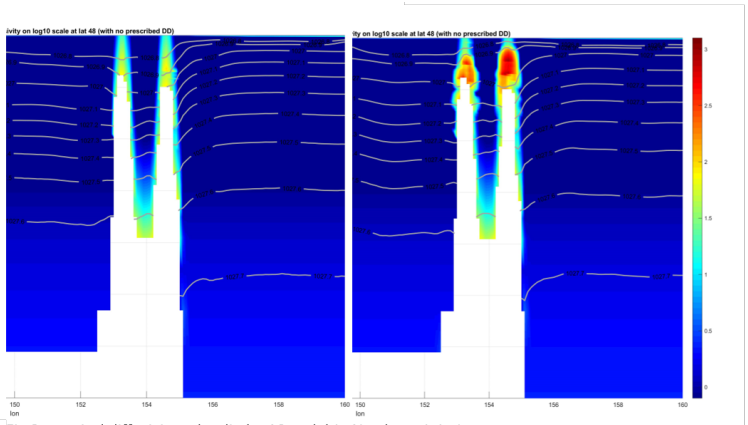

Fig.2: vertical diffusivity value (in log10 scale) in North strait in June, left one is non-tidal run and right is tidal run.

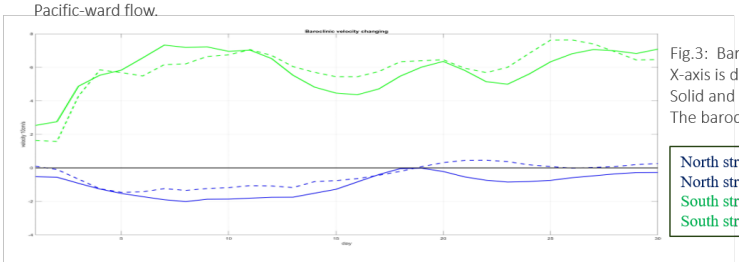

Fig.3: Baroclinic components in the tidal run with non-tidal initial condition.
X-axis is day and y-axis is velocity. Blue line is north strait and green line is south strait.
Solid and dot line are upper and lower isopycal layer, respectively.
The baroclinic velocity is stable after a week running.

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Distributions of organic Fe-binding ligands in the eastern and western subarctic North Pacific

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Iron (Fe) is well known as a key parameter for primary productivity in the ocean. To understand the distributions and biogeochemical cycle of Fe in the ocean, we need to investigate the sources and sinks of Fe. A recent study has demonstrated a concentration gradient of dissolved Fe in the North Pacific Intermediate Water (NPIW) between western and eastern areas (Nishioka and Obata, 2017), suggesting that Fe-rich intermediate water was transported laterally across the western subarctic gyre. Moreover, it has been demonstrated that most dissolved Fe in seawater is complexed with natural organic ligands. Since bioavailability of Fe in seawater depends on its species, the chemical speciation of Fe is needed to evaluate the nutrient status for phytoplankton. However, the distribution of natural organic ligands has not been revealed yet in the subarctic North Pacific. In this study, vertical distributions of organic Fe-binding ligands were investigated in the eastern and western subarctic North Pacific to clarify its impact on Fe cycle. Seawater samples were obtained through the whole water column during GEOTRACES-Japan cruise KH-17-03 using trace metal clean technique to avoid metal contaminations. Filtered seawater samples (<0.2 μm) for organic Fe-binding ligands analysis were collected in acid-washed bottles inside a laminar-flow clean booth, then they were stored at -20°C until just before analysis. The organic Fe-binding ligands' concentration and their conditional stability constants were determined by competitive ligand equilibration-adsorptive cathodic stripping voltammetry (CLE-ACSV) method using salicylaldoxime (Abualhaija and van den Berg, 2014). The concentration and conditional stability constants of organic ligands ranged from 0.7 nM to 5.9 nM and from $10^{10.1}$ M^{-1} to $10^{12.3}$ M^{-1}, respectively. The concentrations of organic ligands exceeded those of dissolved Fe concentration more than 1 nM in all samples except for the surface (10-m) at the Oyashio-Kuroshio transition zone station; consequently >99% of dissolved Fe was estimated to be complexed with these natural organic ligands. At the western station, high concentrations of organic ligands were observed in the intermediate layers (400 –600 m), which hydrographic data (27.2 σ_θ –27.3 σ_θ) were corresponding to the lower NPIW (Yasuda et al., 2004), suggesting that organic Fe-binding ligands might be transported within the lower NPIW.

Keywords: iron, organic ligand, subarctic North Pacific, GEOTRACES

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Chemical and physical speciation of copper in the subarctic North Pacific

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Organic complexation of Cu in seawater plays a major role in controlling the toxicity and bioavailability of Cu for marine microorganism. In this study, we determined the concentrations of Cu and its organic ligands in the soluble and dissolved phases in the subarctic North Pacific. Samples were taken from three stations in the subarctic NorthPacific, CL-2 (western), CL-5 (central) and CL-16 (eastern), during summer 2017.

Concentrations of total dissolved and soluble Cu ranged from 1.28 nM –4.82 nM, and 0.47 nM –2.75 nM, respectively, in the subarctic North Pacific. At both CL-2 and CL-16, soluble Cu accounted for 30% - 100% of total dissolved Cu. The proportion of the soluble Cu fraction was low in surface waters, increased a maximum in the intermediate waters, and decreased slightly in deep waters. Two classes of organic ligands were detected in the surface and intermediate waters of CL-5 and CL-16, and in the intermediate waters of CL-2. In all other depths, only one class of ligand was detected. Concentrations of the stronger ligand (L_1) and weaker ligand (L_2) ranged from 1.02 nM –2.95 nM, and 0.77 nM –8.78 nM, respectively. The distributions of L_1 followed closely that of total dissolved Cu in the surface waters, and no clear trend was observed in the intermediate waters. At CL-2, L_1 mainly existed in the soluble phase, whereas for CL-16, soluble L_1 accounted for 50% - 100% of total dissolved L_1. Concentrations of L_2 were relatively constant throughout the water column but elevated concentrations were detected in the surface waters of CL-5 and in the surface and intermediate waters of CL-16. On the other hand, there were a slight depletion of L_2 in the intermediate waters of CL-2.

Keywords: copper, organic ligands, subarctic North Pacific

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Latitudinal and temporal variations in phytoplankton size structure within mesoscale eddies from space

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Phytoplankton plays a critical role in a number of key ocean processes. One of the most important functions of phytoplankton is to determine the energy transfer efficiency in marine ecosystems. Although the energy flow from the base of the food web to higher trophic levels depends on both the biomass and size structure of phytoplankton community, phytoplankton size structure is particularly important because energy flow in marine pelagic food webs is largely based on size specific predator-prey relationships. Therefore, spatiotemporal dynamics in size structure of phytoplankton community can trigger changes in the ecosystem’ s functioning through trophic cascade effects in the trophic chain. With the development of remote sensing techniques, mesoscale eddies, nearly ubiquitous features of the World Ocean, has been recognizing as important feature for the distribution of phytoplankton not only the direct transport of phytoplankton and eddy trapping, but also the vertical flux of nutrients. Recent studies have examined regional variations in the influence of mesoscale eddies on phytoplankton community. Namely, phytoplankton production is enhanced in cyclonic eddies (CEs) than that of anticyclonic eddies (ACEs) because of upwelling inside the eddy; this view, on the other hand, does not hold for a substantial portion of eddies within oceanic subtropical gyres, the largest ecosystems in the ocean. However, previous efforts have focused mainly on variations in chl*a*, whereas quite a few studies have worked on that in the size structure of phytoplankton community because remote estimations of phytoplankton size structure are newly established techniques during the last decade. Here we improved a chl*a* size distribution (CSD) model which estimates the synoptic size structure of phytoplankton community, to assess the impact of mesoscale eddies on spatiotemporal variations in phytoplankton size structure. Original CSD model was based on the spectral features of the phytoplankton absorption coefficient ($a_{ph}(\lambda)$), which estimation accuracy becomes poor in areas of the low productivity, such as subtropical gyres. To avoid this, we used not only $a_{ph}(\lambda)$ but also chl*a* to improve estimation accuracy of the CSD model. The resulting estimation error of the improved CSD model was the median absolute percent difference of 26.0% between the measured and satellite-matched values, and global distribution of the phytoplankton size structure was reliable even in subtropical gyres. The phytoplankton size structure showed a clear latitudinal variation: larger and smaller assemblages in temperate (>30˚S and >30˚N) and low latitudes (30˚S–30˚N) latitudes, respectively. When comparing the phytoplankton size structure within ACEs and CEs, a larger phytoplankton size structure was found in ACEs especially in low latitudes. This result was consistent with a previous report that ACEs are more productive than CEs in subtropical gyres because of winter mixing. In addition, we found increasing trends ($p < 0.05$) in differences between the phytoplankton size structure within ACEs and CEs in low latitudes for the years 2003–2014, suggesting a growing importance of ACEs for phytoplankton and in turn marine ecosystem. Consequently, this study demonstrates significant advantages of satellite remote sensing for biogeochemical and ecological studies.

Keywords: Satellite, Mesoscale eddy, Phytoplankton

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Structure and impact of the Kuroshio nutrient stream

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Recently the Kuroshio has drawn attention as an important supply route of nutrients in the western North Pacific. However, it is unknown whether nutrient concentrations are enhanced along the jet on isopycnal surfaces, as is the case for the “nutrient stream” along the Gulf Stream. We aim to ascertain the structure of nutrient concentration enhancement along the Kuroshio jet and to estimate the impact of nutrient transport downstream to the Kuroshio-Oyashio interfrontal zone (KOIZ), which is a highly productive region and a major global fishing ground. Recent multiple- transects and retrospective analyses of historic hydrographic data have revealed that the along-jet maximum nitrate concentration appears only in spring on the isopycnal surface $25<\sigma_\theta<26$ in the downstream region of the Kuroshio. The Kuroshio nutrient stream contributes significantly to productivity in the euphotic layer along its downstream trajectory, in conjunction with enhanced vertical turbulence. Analysis of the budget of epipycnal nitrate transport across transects that enclosed the KOIZ suggests that the Kuroshio nutrient stream has a non-negligible potential to significantly impact high productivity in the KOIZ.

Keywords: Kuroshio nutrient stream, Kuroshio-Oyashio interfrontal zone, epipycnal transport

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Enhanced nutrient supply and biogeochemical impacts induced by internal waves in the oligotrophic northern South China Sea

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To understand nutrient supply and the biogeochemical response induced by internal waves in the deep basin of the northern South China Sea (NSCS), nitrate, chlorophyll *a* (Chl *a*), particulate organic carbon (POC) fluxes were measured during the passage of large internal waves using drifting sediment traps attached with hydrographic sensors. Results revealed large variations in temperature, nitrate and chlorophyll *a* (Chl *a*) concentrations during and after internal waves, suggesting that cold nutrient-replete waters may be brought to the euphotic zone in the dissipation zone during and after the passage of internal wave packets, resulted in phytoplankton flourished in oligotrophic water. The result reveals that ocean mixing triggered by internal waves in warm water of the NSCS may be important for phytoplankton species composition. Most importantly, POC fluxes (110.9±10.7 mg C m^{-2} d^{-1}) were significantly enhanced after internal waves compared to non-internal wave area (32.6–73.0 mg C m^{-2} d^{-1}) in the NSCS. Such elevated POC fluxes may be induced by downward flourished biogenic particles, particle aggregation or converged particles from mixed layer triggered by internal waves.

Keywords: internal waves, ocean mixing, South China Sea, nutrient dynamics

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Mixing over the eastern ridge in the Luzon Strait caused by high-mode internal waves

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The Luzon Strait has two parallel ridges running from north to south, which is known to create large amplitude internal tides. To investigate the mixing processes accompanied by the internal tides, we carried out repeated observations with XBT, XCTD, CTD, and ADCP in the cruise of R/V Hakuho-maru KH-17-5, Leg-2, in November 2017 as part of the OMIX project. We obtained 6 cross sections around the eastern ridge between 121° 30’ E and 122° 10’ E along the line of 21° N.

The cross sections showed wavy structures of isopycnals over the ridge, with 4-7 km of horizontal scale and about 50 m of vertical scale. Velocity distributions by the shipboard ADCP showed strong vertical shear over the ridge, suggesting high-mode internal waves. Froude number of the high-mode internal waves exceeds unity around two summits of the ridge during the periods of strong tidal flow. This suggests that the high-mode internal waves stay over the ridge.

Many temperature inversions, especially large inversions ($\theta > 0.05$ °C) were formed near the ridge (figure). Therefore, energy dissipation rate and vertical diffusivity assuming the model of Osborn (1980) were estimated by calculating Thorpe scale from the temperature profiles. Relatively large energy dissipation rate and vertical diffusivity were distributed over the ridge from surface to the bottom, as well as unstable regions of $Ri < 0.25$. These results reflect strong mixing over the ridge due to the high-mode internal waves.

Keywords: internal waves, Luzon Strait

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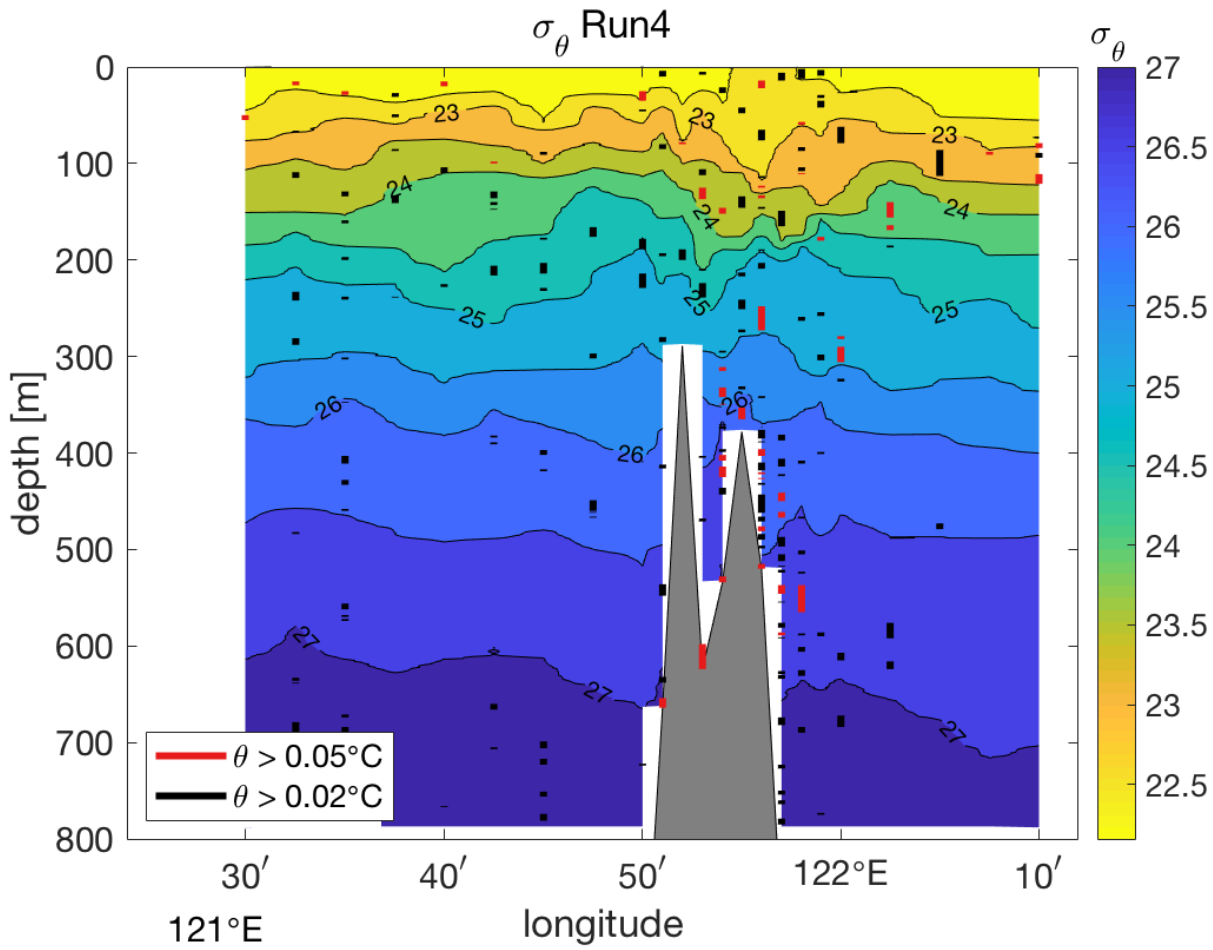

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From the Luzon Strait to the Tsushima Strait: Water masses and nutrient transports approached using ^{137}Cs

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More than 95% of the water flowing into the Sea of Japan comes from the Tsushima Strait, and 80% of it is Kuroshio Intimidate Water (KIW), which is rich in nutrients compared with Kuroshio surface Water and Kuroshio Tropical Water. However, there is a lack of direct evidence based on surveys or measurement data. ^{137}Cs in the subtropical mode water (STMW) that originated in the Fukushima Dai-ichi Nuclear Power Plant (FNPP1) accident is an excellent tracer which can be transported from the Kuroshio upstream to the Sea of Japan crossing the shelf edge of the East China Sea (ECS) via the KIW. It is also useful for research on the transport of nutrients from the KIW.

Data and water samples were collected during the Hakuho-Maru KH-17-5 Cruise and the Nagasaki-Maru 464 Cruise in November and July 2017, respectively. Data from the KH-17-5 Cruise was used for the study of the area around the Luzon Strait and those of the Nagasaki-maru 464 Cruise was used for the study of area around the outer shelf region of the East China Sea and the Tsushima Strait. The ^{137}Cs active concentration was analyzed by γ-Ray spectrometry after preconcentration. The turbulence intensity was measured using TurboMAP and VMP2000.

The maximum ^{137}Cs concentration shows the existence of the subtropical mode water (STMW) in the Luzon Strait, the ECS and the Tsushima Strait, respectively, at the similar density (25.2-25.7 kg/m^3), temperature (15-17℃) and salinity (34.60-34.75). Although their depth changes from 400 m in the Luzon Strait to 150 m at the shelf edge of the ECS and 100m in the East Channel of the Tsushima Strait, they can all be identified as the KIW because of the similar density. It is noteworthy that around Luzon Strait, the distribution of ^{137}Cs is influenced by strong vertical mixing. The percentage of nutrients transported to the Sea of Japan by KIW is estimated and this is meaningful to the ecosystem of the Sea of Japan.

Keywords: 137Cs, subtropical mode water, water masses, KIW, nutrients

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Impact of cyclonic eddies and typhoons on biogeochemistry in the oligotrophic ocean based on time-series observation at the western Pacific subtropical station KEO

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In 2014, a sediment trap mooring experiment started adjacent to station Kuroshio Extension Observatory (KEO)' s National Ocean and Atmosphere Administration (NOAA) surface mooring. Two-years long sediment trap data show that biogenic material fluxes at ~ 5000 m increased between late winter (March) and late spring (June). Based on sea surface temperature and upper ocean water temperature profiles, from the NOAA surface buoy, and satellite-based surface chlorophyll-a , this increase was likely due to an increase of ocean productivity in early spring (March) that was supported by nutrients supplied by winter mixing. On the other hand, biogenic material fluxes also increased in October 2014, and between late December 2014 and January 2015 when concentrations of nutrients near the surface typically are low. Sea surface height anomalies and vertical profiles of water temperature in the upper 500 m showed cyclonic eddies passing station KEO and causing upwelling of middle-layer water in late July–early August 2014 and November 2014. It appears that these events supplied nutrients to the upper layer, which then caused ocean productivity in the subsurface layer to temporally increase, resulting in increased deep biogenic material fluxes in autumn and winter. This interpretation of the data is consistent with a simple 3D physical-biological model simulation that shows meso-scale cyclonic eddies can supply nutrient to support new production at KEO. During the 2-year-long sediment trap deployments, several typhoons also passed near station KEO and near-inertial internal waves were observed near the nitracline depth after the typhoons passed. Although turbulent mixing caused by near-inertial internal wave could have possibly supplied nutrient to upper oligotrophic euphotic layer, numerical simulations of the turbulent nutrient supply indicate that enhanced turbulent diffusion across the nutrient concentration gradient did not supply enough nitrate to support the increase in biogenic material flux in autumn.

Keywords: KEO, Oligotrophic, Sediment trap, Cyclonic eddy, Nutrient, Typhoon

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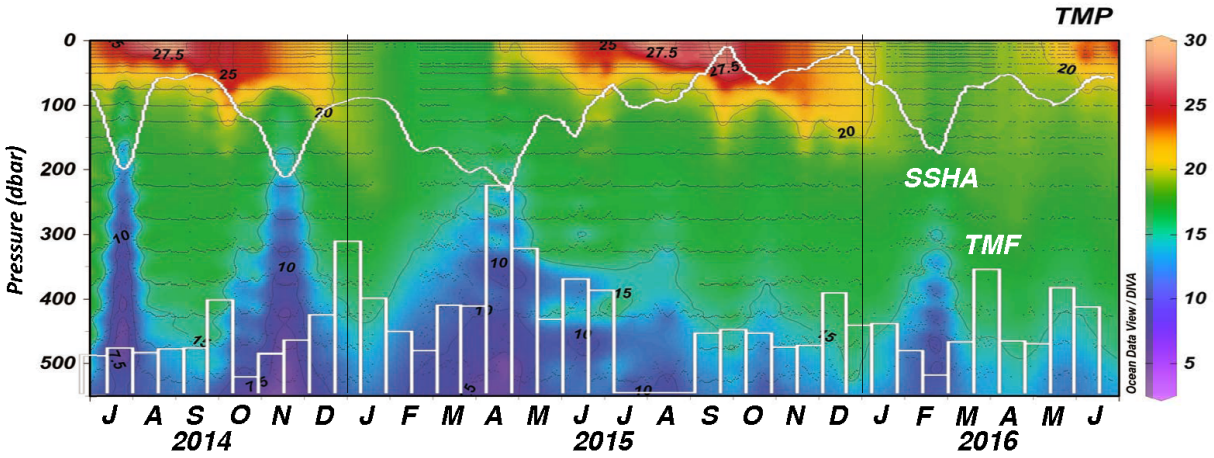

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Island-mass effect on the phytoplankton and zooplankton community in south of Japan

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The Izu Ridge brings high plankton production via its island-mass effect, which brings up subsurface nutrients to surface layer. Previous reports on island-mass effect around the ridge have been based on observation in the summer-early autumn and reports in spring, when many small pelagic fish species spawn, are scarce. As the Kuroshio flow through the ridge, island-mass effect on zooplankton, which takes more time to glow than phytoplankton, should be appear in eastern (downstream) area. Thus wider area around the ridge should be examined for the effect on zooplankton. In the present study, we examined island-mass effect of the Izu-Ridge on phytoplankton and zooplankton, based on satellite data and zooplankton data in the broad area south of the Honshu.
The Sea surface chlorophyll concentration (SSChl, MODIS-Aqua) in the area bounded by 135.5-142.0 E and 30.0-37.0 N was examined for the grids with depths of > 500 m. Zooplankton samples were collected by vertical tow (0-150 m) of the NORPAC net with 0.335 mm mesh in the area south of Honshu in February to March of 1963-2017. Samples were fixed in 5% formalin-sea water and copepod biomass was estimated in the laboratory by Bench-top Video Plankton Recorder. The relationships between plankton biomass and distance to the Honshu coast and to the Izu Ridge were examined.
The SSChl declined as distance to the Honshu coast increased. But high SSChl was observed in several areas 150-250 km away to the coast. These areas were mainly located around the Izu Ridge, 32-33.5N, and interpreted as caused by island-mass effect when the Kuroshio flowed in offshore path. The copepod biomass was high around the Honshu coast (<50 km). Stations with high copepod biomass were observed in the 100-200 km north-east (downstream) of the Izu Ridge, but they were located near the Honshu, around the Boso peninsula. Island-mass effect of the Izu-ridge on zooplankton biomass thus cannot be distinguished from the coastal effect and the effect should be examined by rate process (spawning rate and/or growth rate) in species level.

Keywords: zooplankton, island-mass effect

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Influence of enhanced deep circulation due to geothermal heat on biogeochemical cycle in the Pacific Ocean

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There exists heat conduction from the oceanic lithosphere to the abyssal ocean. Its heat flux amounts to about 0.1 W m^{-2} in the global average. It is much smaller than the heat exchange between the atmosphere and ocean in the order of 10 W m^{-2}. However, it is known that this geothermal heat significantly enhances the deep circulation especially in the Pacific Ocean. For example, Adcroft et al. (2001) conduct numerical experiments with/without geothermal heating using an ocean general circulation model and report that constant heat flux at the sea bottom by 0.05 W m^{-2} results in enhancement of the Pacific meridional overturning circulation (PMOC) by 25 %. Other studies also report that the geothermal heat significantly enhances the oceanic deep circulation (e.g., Emile-Geay and Madec, 2009; Urakawa and Hasumi, 2009; Downes et al., 2016). The importance of the geothermal heat seems to be robust from the viewpoint of ocean dynamics but it has not been investigated to what extent the geothermal heat influences the biogeochemical cycle of the ocean. Here, we conduct two numerical experiments with/without the geothermal heat using an ocean general circulation model developed for the CMIP6 and investigate the effect of the geothermal heat on the biogeochemical tracer fields.
The geothermal heating enhances PMOC at 30º S by 17 % in this model, which leads to stronger ventilation in the North Pacific Ocean. This stronger ventilation results in increase of delta ^{14}C by more than 10 per mille, which means younger water masses, at the bottom of the North Pacific. The stronger PMOC also results in higher dissolved oxygen in the abyss especially in the eastern tropical Pacific. The geothermal heat leads to dissolved oxygen increase by more than 10 micro mol L^{-1} there, which corresponds to 10–70 % of hypoxic water in the control experiment without geothermal heating. This oxygenation near the sea bottom affects the oxygen-deficient water in the surface of the eastern tropical Pacific. Its thickness becomes thinner by around 100 m. The geothermal heat also plays an important role in the biogeochemical cycle in the Pacific Ocean.

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The Parameterization of the Pressure-Strain Correlations in the Stably or Unstably Stratified Ocean Surface Layer.

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Turbulence in the ocean surface layer mixes momentum, heat, and nutrient vertically. It is therefore important for air-sea interaction, phytoplankton blooming, and other oceanic processes (e.g., Roxy et al. 2013; Obata et al. 1996). However, large-scale models such as ocean general circulation models cannot explicitly resolve small-scale turbulence because of their coarse resolution. For this reason, the vertical mixing should be parameterized using the turbulent closure scheme that successfully parameterizes the turbulent mixing. Recently, attention is paid to pressure-strain correlations, which redistribute stress due to fluctuating pressure, in the parameterization scheme used for engineering purposes (Jakilic and Hanjalic 2013). In the present study, therefore, the validity of the pressure-strain correlation parameterization used in the ocean (or atmosphere) (Rotta 1951, Gibson and Launder 1978, Gertski et al. 1992) was examined. To this end, we performed Large-eddy simulations of ocean surface boundary layer to simulate pressure-strain correlations and compared it with parameterized correlations. Here, we focused on the effects of stratification on the correlations, because the stratification is an essential factor in the ocean and atmospheric boundary layers but previous schemes did not include the stratification effects sufficiently. Results show that the parameterizations of the pressure-strain correlations had systematic errors depending on the stability (or stratification). It was also found that the error can be reduced by introducing new parameters related to the stability into the scheme.

Keywords: Parameterization of Pressure-Strain Correlations, Turbulent Closure Model, Turbulence in the Ocean Surface Layer

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Numerical studies on asymmetric responses of the upper ocean to tropical cyclone

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Tropical cyclones (TCs) decrease sea surface temperature (SST), and the decreased SST weakens TC intensity. This SST decrease is asymmetric with respect to the TC track, known as “rightward bias”. Preceding numerical studies suggested that this asymmetry may influence on the course of the TC. The interaction between TC and the upper ocean is one of key ingredients for precisely predicting TC's development, and the upper ocean response to TC should also be clarified.
The SST decrease during TC passage is mainly caused by two processes; vertical turbulent mixing and advection (Ekman suction). The rightward bias is associated with the mixing which is more intense on the right side of the TC track due to resonant inertial currents with winds. Magnitude and distribution of SST decrease induced by the mixing should vary with parameters characterizing TC; transition speed U_T, radius of maximum wind R_{max}, the friction velocity U_*, and the Coriolis coefficient f. However, detailed physical processes of the mixing and its dependence on these parameters have not been well quantified, because of lack of in-situ data and complicated processes involved in the mixing.

The present study focuses on the vertical turbulent mixing effects on asymmetric SST response. To this aim, vertically one-dimensional model was used in which the vertical turbulent mixing was parameterized with the Nakanishi-Niino-Mellor-Yamada scheme modified by Kitamura (2010). We considered TC-like wind stress of magnitude U_*^2 at radius R_{max} from the TC center moving with transition speed U_T and investigated the mixing on both sides of TC track at distance *r*. Experiments with several friction velocities U_*, maximum wind radii R_{max}, transition speeds U_T and distances *r* were performed. No surface heat flux was considered for simplicity.
The results showed that the rightward bias of the SST response depended on these parameters. The location of the largest SST decrease moved away from the axis as U_T increased, but it depended less on U_*. The SST decreased more with larger U_* and smaller U_T. These results can be explained by energy flux at the surface. In our model configuration, the energy flux depends on two non-dimensional parameters, U_T/fR_{max} and U_*/U_T, and the energy flux had maximum and turbulent kinetic energy penetrated deeper at larger U_*/U_T and at U_T/fR_{max}~1, suggesting the resonance between wind and the inertial current. The SST decrease corresponded with the energy flux, but it depended largely on U_*/U_T, implying importance of wind forcing duration.
Thus, the asymmetric SST response due to the vertical turbulent mixing can be characterized with U_T/fR_{max} and U_*/U_T. Additional advection effects on the SST response will be discussed at the conference using three-dimensional simulation in which the advection as well as the mixing are fully included.

Keywords: Tropical cyclone, Vertical turbulent mixing, Ekman suction, Rightward bias

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Influence of the distortion of the internal wave field on estimates of turbulent mixing using fine-scale parameterizations

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1. Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2. National Oceanography Centre, University of Southampton

Although the Southern Ocean is one of the turbulent mixing hotspots, we have not yet clarified quantitatively the turbulent mixing processes in this region, where the Antarctic Circumpolar Current (ACC) coexists with near-inertial internal waves generated by wind forcing and internal lee waves radiated by the impingement of eddy flows on topography.

Fine-scale parameterizations, based on the theory of energy cascade from internal waves to turbulence, are most widely used to estimate the turbulent dissipation rate, ε. It has been reported, however, that these fine-scale parameterizations tend to overestimate ε in the ACC (Waterman et al. 2014). Although Takahashi and Hibiya (2019) have suggested that "the distorted fine-scale shear and strain spectra" caused by the existence of eddies trapping near-inertial waves or upward-propagating internal lee waves might be responsible for the overestimates, the problem remains unresolved.

In this study, we use "eikonal" simulations (Henyey et al. 1986), which trace the propagation, refraction and breaking of test waves within a background internal wave field, to assess the evolution of the energy cascade in vertical wavenumber space. Our objective is to examine how the distortion of the vertical wavenumber spectrum affects the performance of fine-scale parameterizations.

In our simulations, in contrast to high vertical wavenumber test waves that are efficiently Doppler-shifted to their breaking limit, low vertical wavenumber test waves are not subject to dissipation processes. In the existing fine-scale parameterizations, however, the energy flux to dissipation scale is estimated using the integrated vertical wavenumber spectral values. This means that, if the range of this integration includes a spectral bump at the low-wavenumber end of the spectrum, the estimated energy flux and hence the resulting ε might be overestimated by these fine-scale parameterizations.

From the simulation results, it is confirmed that fine-scale parameterizations significantly overestimate ε in spectra with a low-wavenumber bump, in particular as the internal wave energy level becomes large and the shear/strain ratio becomes small. These results are supported by the microstructure and fine-structure dataset from the SOFine experiment carried out in the Kerguelen Plateau.

Keywords: Turbulent Mixing, Fine-scale parameterizations, Antarctic Circumpolar Current region

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[E] Poster | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_11

[A-OS09] Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem

convener:Ichiro Yasuda(Atmosphere and Ocean Research Institute, The University of Tokyo), Toshiyuki Hibiya(Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo), Jun Nishioka(Hokkaido University, Institute of low temperature sciences), Shin-ichi Ito(Atmosphere and Ocean Research Institute, The University of Tokyo)

The interdisciplinary study on ocean diapycnal mixing and its impacts (Ocean Mixing Processes: Impact on Biogeochemistry, Climate and Ecosystem (OMIX) 2015-2020) is opening the integrated sciences from physical, chemical, biological oceanography to climate and fisheries sciences. In this section, results during the four years of OMIX projects and other related presentations are all welcome to be summarized and to facilitate plans of next projects.

[AOS09-P01] Correction method of fast-response thermistors data to estimate turbulence intensity

*kimura shino[1], Yasutaka Goto[2], Koenjong Lee[1], Ichiro Yasuda[1] (1.The Univercity of Tokyo, 2.Meteorological Agency)

[AOS09-P02] Observation of turbulent mixing using a deep float with microstructure sensors

*Shuo Zhai[1], Ichiro Yasuda[1], Masaaki Kikuchi[1], Yasutaka Goto[1], Koenjong Lee[1], Takahiro Tanaka[2], Ken Yamaki[3], Yutaka Imamura[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Japan Fisheries Research Agency, 3.TSK Tsurumi-Seiki Co., Ltd., 4.Aomori Prefectural Industrial Thechnology Research Center, Fisheries Research Insititute)

[AOS09-P03] Evaluation of the underwater glider flight model using the electromagnetic current sensor

*Takahiro Tanaka[1], Daisuke Hasegawa[1], Takeshi Okunishi[1], Ichiro Yasuda[2] (1.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 2.Atmosphere and Ocean Research Institute, University of Tokyo)

[AOS09-P04] Mixing processes observed by a slocum glider at the Oyashio-TWC front

*Daisuke Hasegawa[1], Takahiro Tanaka[1], Takeshi Okunishi[1], Ichiro Yasuda[2] (1.Tohoku National Fisheries Research Institute, Japan Fisheries Research and Education Agency, 2.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P05] Impact of the astronomical lunar 18.6-yr tidal cycle on El-Niño and Southern Oscillation

*Ichiro Yasuda[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P06] The effect of 18.6-year period lunar nodal cycle on Pacific Decadal Oscillation (PDO)

*Masaki Hamamoto[1], Ichiro Yasuda[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P07] A comparison of ocean deoxygenation between CMIP5 models and an observational dataset

*Yumi Abe[1], Shoshiro Minobe[1,5], Takamitsu Ito[2], Curtis Deutsch[3], Matthew C. Long[4] (1.Department of Natural History Sciences, Graduate School of Science,Hokkaido University, Sapporo, Japan, 2.School of Earth and Atmospheric Sciences, Georgia Institute of Technology, Atlanta, Georgia, USA, 3.School of Oceanography, University of Washington, Seattle, Washington, USA, 4.Climate and Global Dynamics

Laboratory, National Center for Atmospheric Research, Boulder, Colorado, USA, 5.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, Sapporo, Japan)

[AOS09-P08] Pacific Ocean State Estimation and Clarification of Mechanism of Ocean Circulation by Data Synthesis of Global Observations

*Shuhei Masuda[1] (1.Japan Agency for Marine-Earth Science and Technology)

[AOS09-P09] Impact of Tidal Vertical Mixing to Barotropic Water Exchange between the Sea of Okhotsk and Pacific through Diffusive Adjustment with Turbulent Closure Scheme

*Hung Wei Chou[1], Humio Mitsudera[1], Hatsumi Nishikawa[1], Kaihe Yamazaki[2] (1.Hokkaido University, Institute of Low Temperature Science, 2.Hokkaido University, Graduate School of Environmental Science)

[AOS09-P10] Distributions of organic Fe-binding ligands in the eastern and western subarctic North Pacific

*Yoshiko Kondo[1,2], Yudai Sunahara[2], Jun Nishioka[3], Hajime Obata[4], Shigenobu Takeda[1,2] (1.Graduate School of Fisheries and Environmental Sciences, Nagasaki University, 2.Faculty of Fisheries, Nagasaki University, 3.Institute of Low Temperature Science, Hokkaido University, 4.Atmosphere and Ocean Research Institute, The University of Tokyo)

[AOS09-P11] Chemical and physical speciation of copper in the subarctic North Pacific

*Kuo Hong Wong[1], Hajime Obata[1], Taejin Kim[2], Yoshiko Kondo[3], Jun Nishioka[4] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Seoul National University, Korea, 3.Nagasaki University, 4.Institute of Low Temperature Science, Hokkaido University)

[AOS09-P12] Latitudinal and temporal variations in phytoplankton size structure within mesoscale eddies from space

*Hisatomo Waga[1], Toru Hirawake[1], Ueno Hiromichi[1] (1.Hokkaido University)

[AOS09-P13] Structure and impact of the Kuroshio nutrient stream

*Kosei Komatsu[1,2], Yutaka Hiroe[3] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, Kashiwa, Japan, 3.Seikai National Fisheries Research Institute, Japan Fisheries Research and Education Agency, Nagasaki, Japan)

[AOS09-P14] Enhanced nutrient supply and biogeochemical impacts induced by internal waves in the oligotrophic northern South China Sea

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[AOS09-P15] Mixing over the eastern ridge in the Luzon Strait caused by high-mode internal waves

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[AOS09-P16] **From the Luzon Strait to the Tsushima Strait: Water masses and nutrient transports approached using ^{137}Cs**

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[AOS09-P17] Impact of cyclonic eddies and typhoons on biogeochemistry in the oligotrophic ocean based on time-series observation at the western Pacific subtropical station KEO

*Makio Honda[1], Yoshikazu Sasai[1], Eko Siswanto[1], Akira Kuwano-Yoshida[2], Hidenori AIKI[3], Meghan Cronin[4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Disaster Prevention Laboratory, Kyoto University, 3.Nagoya University, 4.NOAA Pacific Marine Environmental Laboratory)

[AOS09-P18] Island-mass effect on the phytoplankton and zooplankton community in south of Japan

*Kiyotaka Hidaka[1], Kazuaki Tadokoro[1], Hiroomi Miyamoto[1], Tadafumi Ichikawa[1] (1.Japan Fisheries Research and Education Agency)

[AOS09-P19] Influence of enhanced deep circulation due to geothermal heat on biogeochemical cycle in the Pacific Ocean

*Shogo Urakawa[1], Hideyuki Nakano[1], Hiroyuki Tsujino[1], Kei Sakamoto[1], Takahiro Toyoda[1], Goro Yamanaka[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

[AOS09-P20] The Parameterization of the Pressure-Strain Correlations in the Stably or Unstably Stratified Ocean Surface Layer.

*Yusuke Ushijima[1], Yutaka Yoshikawa[1] (1.Graduate School of Science, Kyoto University)

[AOS09-P21] Numerical studies on asymmetric responses of the upper ocean to tropical cyclone

*Daiki Okura[1], Yutaka Yoshikawa[1] (1.Graduate School of Science, Kyoto University)

[AOS09-P22] Influence of the distortion of the internal wave field on estimates of turbulent mixing using fine-scale parameterizations

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Correction method of fast-response thermistors data to estimate turbulence intensity

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Fast-response thermistors (FP07) can be used to estimate turbulent energy dissipation rate ε and temperature dissipation rate χ. However, correction is necessary because the insufficient response of FP07 causes underestimate for relatively strong turbulence and individual FP07 sensors have different response. In this study, using simultaneously observed shear probe and FP07 data from a free fall microstructure profiler descending at the speed of 0.6-0.7 m/s, ε_T from various FP07 are compered with ε_S from shear probe to estimate how much correction is necessary for FP07 data. For 3 (7) msec time constant of FP07 for double-pole (single-pole) correction, ε_T is consistent with ε_S within a factor of 3 in the range of ε_S =10^-10 ~10^-7 W/kg. In the presentation we also discuss the impact of correction on χ and the validity of ε_T under double diffusion.

Keywords: vertical mixing, turbulence

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Observation of turbulent mixing using a deep float with microstructure sensors

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Automated microstructure obsevation method using a deep float (DeepNINJA) with velocity shear probe and fast-response thermistor is being elaborated. From the field test observation in August 2016, availability of shear probe data was tested by comparing turbulent dissipation rates from thermistor. Shear probe data were found to be worse by vibration from motor operartions at buoyancy adjustment and by noise at slow ascending speed of the float. Vertical profiles of turbulent energy dissipation rate could be obtained with the hybrid use of shear probe and thermistor data by correcting time-constant of the termistor with reliable shear probe data and filling gaps of unavailable shear probe data. Data will be reported for the deep float which was deployed on December 12, 2018, in the western slope of Japan Trench off Aomori. The float is observing 0 - 4000 m turbulence profile every 10 days and will be recovered in April R/V Shinsei-maru cruise.

Keywords: vertical mixing , deep float, energy dissipation rate

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Evaluation of the underwater glider flight model using the electromagnetic current sensor

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Turbulence measurement by underwater gliders has become more common in recent years. For the accurate estimation of energy dissipation rates, the accurate measurement of the fall rate and gliding path angle is necessary. The gliding path angle should take the angle of attack (AOA) into account, which is the difference between the gliding path angle and the pitch angle. AOA calculation has been done by using the so-called flight model assuming dynamical force balance in the quasi-steady state. Due to the difficulty in measuring AOA directly, the validity of AOA derived from the flight model and the flight model itself has not been adequately evaluated so far. In this study, we put the electromagnetic current sensor (EM sensor) on the turbulence package to obtain AOA directly and to compare the AOA from EM sensor with that from the flight model. Using the dataset obtained by a Slocum glider in Jul. - Aug. 2017, we found that AOA from the EM sensor during descent and ascent has a mean (standard deviation) of 0.7 (1.2) deg. and -0.7 (1.1) deg., respectively, while AOA from the flight model is 4.9 (0.4) deg. and -4.5 (0.5) deg., respectively. In order to know what cause this difference, we discuss the validity of parameters given in the flight model. It is suggested that a drag coefficient due to parasite drag given in the flight model may be somewhat larger than that calculated using the EM sensor.

Keywords: underwater glider, flight model, electromagnetic current sensor, angle of attack

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Mixing processes observed by a slocum glider at the Oyashio-TWC front

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In order to grasp the detailed mixing processes along the frontal region between the Oyashio and the Tsugaru Warm Current (TWC), we conducted a zigzag survey crossing the front several times from the merging region of the two current systems to the down stream by an underwater glider (Slocum G2 Glider) equipped with a turbulence sensor, from July 24thto August 29thin 2017. The observed frontal structure indicated the subduction and the intrusion processes of the cold and fresh Oyashio water under the warm and salty TWC water, along layer between 26.5 to 26.8 sigma-theta, which resulted the favorable conditions to the salt finger convection at the upper interface along the 26.5 sigma-theta, and the diffusive convection at the lower interface along the 26.8 sigma-theta where the fresh and cold Oyashio water lying above the warm and salty water. The strong turbulence intensity is observed around the intruded layer, and the mean temperature and the salinity in the layer became warmer and saltier with the increase of the distance from the front, which suggested the time evolution of the vertical mixing driven by double diffusive convections between the three different water masses. Though the strongest turbulence intensity was observed around the frontal region, which may suggest the importance of the cabbeling effect as the additional source of the turbulent mixing.

Keywords: double diffusion, mixing, cabbeling

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Impact of the astronomical lunar 18.6-yr tidal cycle on El-Niño and Southern Oscillation

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Even though El-Niño and Southern Oscillation (ENSO) has a tremendous impact on global climate and society, its long-term forecast remains difficult. In this study, we discovered a statistically significant relationship between ENSO timing and the 18.6-year period lunar tidal cycle in the mature-phase (December –February) ENSO time-series during 1867–2015 and extending back to 1706 with proxy data. It was found that El-Niño tended to occur in the 1st, 10th, and 13th years after the maximum diurnal tide in the 18.6-yr cycle, and La-Niña tended to occur in the 3rd, 12th, and 16th years. These tendencies were also confirmed by corresponding sea-surface temperature (SST) and sea-level pressure (SLP) distributions; particularly Pacific SST and SLP spatial patterns in the third La-Niña and the tenth El-Niño year well resemble those of Pacific Decadal Oscillation (PDO). These findings contribute to understanding and forecasting long-term ENSO variability.

Keywords: El-Niño and Southern Oscillation, air-sea interaction, tide, mixing, climate

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The effect of 18.6-year period lunar nodal cycle on Pacific Decadal Oscillation (PDO)

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Pacific Decadal Oscillation (PDO) is the most dominant decadal-inter-decadal ocean-climate variability over the North Pacific; however, the periodicity and cause have not been fully understood. Previous studies suggested that 18.6-year period lunar tidal cycle ($T_{18.6}$) regulate bi-decadal PDO variability through changes in the strength of diapycnal mixing of ocean around the Kuril Islands to result in ocean variability, together with air-sea interactions in the mid-latitude North Pacific and/or equatorial Pacific. In the present study, 297yr-long reconstructed PDO timeseries was re-examined, and 27.9yr (3/2 times 18.6-yr, henceforth, $T_{27.9}$) period variability was significantly detected, and the zero-crossing from minus to plus was found to occur simultaneously with $T_{18.6}$ variability in the interval of 55.4 years (3 times $T_{18.6}$). In the PDO spectrum, a broad multi-decadal 50-80-yr peak (corresponding to 3-5 times $T_{18.6}$, henceforth T_M) was also detected with the zero-crossing synchronized with $T_{18.6}$; this is the extension of previous studies during 1900-2000 back to 1700s on the synchronous changes of bi-decadal and penta-decadal variabilities. These $T_{18.6}$, $T_{27.9}$ and T_M explain 71% of the 10-year low-passed PDO variability. These imply that the 27.9-yr and the multi-decadal variabilities could be related to $T_{18.6}$ tide-induced variability, and may be excited by $T_{18.6}$ tidal forcing, considering that external periodic forcing for delayed oscillator models could excite 3 times period of the external forcing and some non-linear processes may make the half-period variability.

Keywords: 18.6-year period lunar nodal cycle, Pacific Decadal Oscillation

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A comparison of ocean deoxygenation between CMIP5 models and an observational dataset

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Recent studies revealed that the ocean deoxygenation has been accelerating since the 1980s over the global oceans (Schmidtko et al. 2017; Ito et al. 2017), and the observed trend in the last half-century appears to be much larger than the model simulations conducted for CMIP5 (Bopp et al. 2013). This discrepancy is an important issue of the ocean deoxygenation researches as highlighted by a review paper published in the last year (Oschlies et al. 2018).

In order to understand better the relations of oxygen variations between CMIP5 models and observations, we compare oxygen concentration simulated by CMIP5 models and gridded oxygen anomaly dataset used by Ito et al. (2017). For the global oceans, the observed oxygen reduction rate for the historical experiment period appears to be within uncertainty of the models, though this result can be sensitive to the choice of the analysis period associated with the rapid recent oxygen reduction. We also closely examined the two basins that are relatively well sampled, i.e., the North Pacific and the North Atlantic. It is found that the observed North Pacific oxygen reduction is much stronger than the simulated ones, but such a strong reduction of observed oxygen does not occur in the North Atlantic. These results suggest that there are substantial spatio-temporal variations of oxygen concentration on decadal timescales and their mechanism in each basin should be explored in future studies.

Keywords: North Pacific, North Atlantic

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Pacific Ocean State Estimation and Clarification of Mechanism of Ocean Circulation by Data Synthesis of Global Observations

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Our aim is to synthesize pre-existing ocean data with newly-acquired turbulence data using state-of-art assimilation technique. Available observations of turbulence strength in the ocean, will be “blended” with pre-existing ocean data applying dynamically self-consistent state estimation approach with 4D-VAR adjoint system. We propose some new techniques and schemes to assimilate turbulence data, which tends to include unique features. The obtained state estimation will provide improved description of ocean circulation, its heat and salt transports, and oceanic ecosystem at lower trophic level.

Keywords: OMIX, ocean , mixing , data assimilation

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Impact of Tidal Vertical Mixing to Barotropic Water Exchange between the Sea of Okhotsk and Pacific through Diffusive Adjustment with Turbulent Closure Scheme

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The pattern of exchange flow between the Sea of Okhotsk and Pacific is a system composed by an Okhotsk-ward inflow through Kruzenshtern strait in north and a Pacific-ward outflow through Bussol strait in south. One of major theories for explaining the dynamic of water exchange through Kuril Island Chain is the turbulence induced by tidal vertical mixing. Turbulence is an important physical process in geostrophic boundary layer, and because of the complexity of topographic in Kuril island chain, the breaking of internal tides in island coast area leads to increase the thickness of surface mixing layer and causes tilting of isopycnal layer in vicinity. The tilting of isopycnal layer around islands forms a clockwise flow along the shore by geostrophic adjustment. However, above process is majorly broclinicly, and how can it impact to barotropic component is still unknown.

By setting the tidal force as a controlled variable, results from realistic OGCM model COCO show only the case with tidal forcing can consistent with the exchange flow pattern as historical observation (Fig.1). Besides, the vertical diffusivity values also show the magnitude difference in summer time, which the flow in north strait in non-tidal case is opposite to tidal one (Fig.2). Therefore, we designed four experiments for understanding the impact of tidal diffusive adjustment in summer: 1. install vertical diffusivity value generated by tidal case into non-tidal run; 2. install vertical diffusivity value generated by non-tidal case into tidal run; 3. set the vertical diffusivity value as zero in tidal case and 4. in non-tidal case as well. Further, for preventing the underestimates the depth of the mixing layer in Mellor-Yamada turbulence closure scheme, two more experiments with the larger vertical diffusivity mask are applied in both tidal and non-tidal case. After calculating the fraction of baroclinic and barotropic components in either north strait or southern strait, results show the vertical mixing dose influence the strength of volume transported but not the direction as original tidal and non-tidal case shows. Hence, for further understanding the impact of vertical diffusivity, we start a tidal forcing run with non-tidal initial conditions to detect the relationship between the flow direction and magnitiude of vertical diffusivity values by time developing. But the baroclinic result implies that the vertical mixing might not be the main reason to control the flow direction (Fig.3).

This study also implies the tidal impacts in OGCM is not only the vertical mixing, but other geostrophic fluid dynamics might occur, especially the interaction of topography with tidal waves. Therefore, for reproducing the real ocean phenomena, movement of tidal waves should be considered.

Keywords: OGCM, tidal mixing , Okhotsk, cross-basin exchange system

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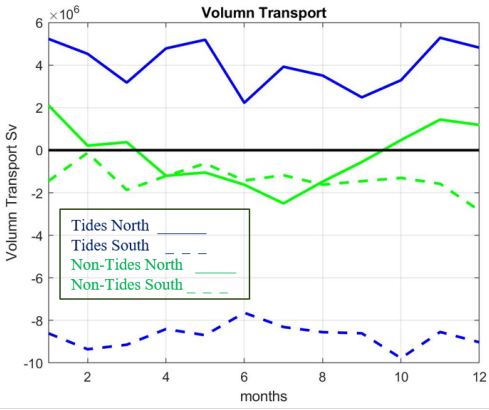

Fig.1: volume transportation in tidal and non-tidal run.
Positive value is Okhotsk-ward and negative value is Pacific-ward flow.

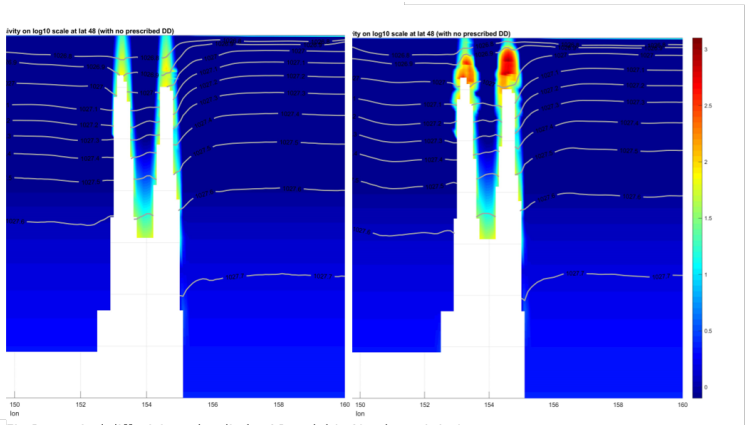

Fig.2: vertical diffusivity value (in log10 scale) in North strait in June, left one is non-tidal run and right is tidal run.

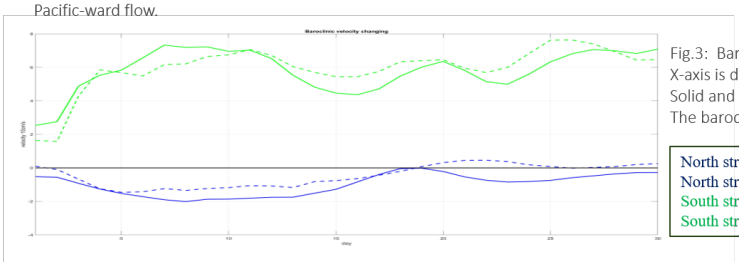

Fig.3: Baroclinic components in the tidal run with non-tidal initial condition.
X-axis is day and y-axis is velocity. Blue line is north strait and green line is south strait.
Solid and dot line are upper and lower isopycal layer, respectively.
The baroclinic velocity is stable after a week running.

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Distributions of organic Fe-binding ligands in the eastern and western subarctic North Pacific

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Iron (Fe) is well known as a key parameter for primary productivity in the ocean. To understand the distributions and biogeochemical cycle of Fe in the ocean, we need to investigate the sources and sinks of Fe. A recent study has demonstrated a concentration gradient of dissolved Fe in the North Pacific Intermediate Water (NPIW) between western and eastern areas (Nishioka and Obata, 2017), suggesting that Fe-rich intermediate water was transported laterally across the western subarctic gyre. Moreover, it has been demonstrated that most dissolved Fe in seawater is complexed with natural organic ligands. Since bioavailability of Fe in seawater depends on its species, the chemical speciation of Fe is needed to evaluate the nutrient status for phytoplankton. However, the distribution of natural organic ligands has not been revealed yet in the subarctic North Pacific. In this study, vertical distributions of organic Fe-binding ligands were investigated in the eastern and western subarctic North Pacific to clarify its impact on Fe cycle. Seawater samples were obtained through the whole water column during GEOTRACES-Japan cruise KH-17-03 using trace metal clean technique to avoid metal contaminations. Filtered seawater samples (<0.2 μm) for organic Fe-binding ligands analysis were collected in acid-washed bottles inside a laminar-flow clean booth, then they were stored at -20°C until just before analysis. The organic Fe-binding ligands' concentration and their conditional stability constants were determined by competitive ligand equilibration-adsorptive cathodic stripping voltammetry (CLE-ACSV) method using salicylaldoxime (Abualhaija and van den Berg, 2014). The concentration and conditional stability constants of organic ligands ranged from 0.7 nM to 5.9 nM and from $10^{10.1}$ M^{-1} to $10^{12.3}$ M^{-1}, respectively. The concentrations of organic ligands exceeded those of dissolved Fe concentration more than 1 nM in all samples except for the surface (10-m) at the Oyashio-Kuroshio transition zone station; consequently >99% of dissolved Fe was estimated to be complexed with these natural organic ligands. At the western station, high concentrations of organic ligands were observed in the intermediate layers (400 –600 m), which hydrographic data (27.2 σ_θ –27.3 σ_θ) were corresponding to the lower NPIW (Yasuda et al., 2004), suggesting that organic Fe-binding ligands might be transported within the lower NPIW.

Keywords: iron, organic ligand, subarctic North Pacific, GEOTRACES

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Chemical and physical speciation of copper in the subarctic North Pacific

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Organic complexation of Cu in seawater plays a major role in controlling the toxicity and bioavailability of Cu for marine microorganism. In this study, we determined the concentrations of Cu and its organic ligands in the soluble and dissolved phases in the subarctic North Pacific. Samples were taken from three stations in the subarctic NorthPacific, CL-2 (western), CL-5 (central) and CL-16 (eastern), during summer 2017.

Concentrations of total dissolved and soluble Cu ranged from 1.28 nM –4.82 nM, and 0.47 nM –2.75 nM, respectively, in the subarctic North Pacific. At both CL-2 and CL-16, soluble Cu accounted for 30% - 100% of total dissolved Cu. The proportion of the soluble Cu fraction was low in surface waters, increased a maximum in the intermediate waters, and decreased slightly in deep waters. Two classes of organic ligands were detected in the surface and intermediate waters of CL-5 and CL-16, and in the intermediate waters of CL-2. In all other depths, only one class of ligand was detected. Concentrations of the stronger ligand (L_1) and weaker ligand (L_2) ranged from 1.02 nM –2.95 nM, and 0.77 nM –8.78 nM, respectively. The distributions of L_1 followed closely that of total dissolved Cu in the surface waters, and no clear trend was observed in the intermediate waters. At CL-2, L_1 mainly existed in the soluble phase, whereas for CL-16, soluble L_1 accounted for 50% - 100% of total dissolved L_1. Concentrations of L_2 were relatively constant throughout the water column but elevated concentrations were detected in the surface waters of CL-5 and in the surface and intermediate waters of CL-16. On the other hand, there were a slight depletion of L_2 in the intermediate waters of CL-2.

Keywords: copper, organic ligands, subarctic North Pacific

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Latitudinal and temporal variations in phytoplankton size structure within mesoscale eddies from space

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Phytoplankton plays a critical role in a number of key ocean processes. One of the most important functions of phytoplankton is to determine the energy transfer efficiency in marine ecosystems. Although the energy flow from the base of the food web to higher trophic levels depends on both the biomass and size structure of phytoplankton community, phytoplankton size structure is particularly important because energy flow in marine pelagic food webs is largely based on size specific predator-prey relationships. Therefore, spatiotemporal dynamics in size structure of phytoplankton community can trigger changes in the ecosystem’ s functioning through trophic cascade effects in the trophic chain. With the development of remote sensing techniques, mesoscale eddies, nearly ubiquitous features of the World Ocean, has been recognizing as important feature for the distribution of phytoplankton not only the direct transport of phytoplankton and eddy trapping, but also the vertical flux of nutrients. Recent studies have examined regional variations in the influence of mesoscale eddies on phytoplankton community. Namely, phytoplankton production is enhanced in cyclonic eddies (CEs) than that of anticyclonic eddies (ACEs) because of upwelling inside the eddy; this view, on the other hand, does not hold for a substantial portion of eddies within oceanic subtropical gyres, the largest ecosystems in the ocean. However, previous efforts have focused mainly on variations in chl*a*, whereas quite a few studies have worked on that in the size structure of phytoplankton community because remote estimations of phytoplankton size structure are newly established techniques during the last decade. Here we improved a chl*a* size distribution (CSD) model which estimates the synoptic size structure of phytoplankton community, to assess the impact of mesoscale eddies on spatiotemporal variations in phytoplankton size structure. Original CSD model was based on the spectral features of the phytoplankton absorption coefficient ($a_{ph}(\lambda)$), which estimation accuracy becomes poor in areas of the low productivity, such as subtropical gyres. To avoid this, we used not only $a_{ph}(\lambda)$ but also chl*a* to improve estimation accuracy of the CSD model. The resulting estimation error of the improved CSD model was the median absolute percent difference of 26.0% between the measured and satellite-matched values, and global distribution of the phytoplankton size structure was reliable even in subtropical gyres. The phytoplankton size structure showed a clear latitudinal variation: larger and smaller assemblages in temperate (>30˚S and >30˚N) and low latitudes (30˚S–30˚N) latitudes, respectively. When comparing the phytoplankton size structure within ACEs and CEs, a larger phytoplankton size structure was found in ACEs especially in low latitudes. This result was consistent with a previous report that ACEs are more productive than CEs in subtropical gyres because of winter mixing. In addition, we found increasing trends ($p < 0.05$) in differences between the phytoplankton size structure within ACEs and CEs in low latitudes for the years 2003–2014, suggesting a growing importance of ACEs for phytoplankton and in turn marine ecosystem. Consequently, this study demonstrates significant advantages of satellite remote sensing for biogeochemical and ecological studies.

Keywords: Satellite, Mesoscale eddy, Phytoplankton

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Structure and impact of the Kuroshio nutrient stream

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Recently the Kuroshio has drawn attention as an important supply route of nutrients in the western North Pacific. However, it is unknown whether nutrient concentrations are enhanced along the jet on isopycnal surfaces, as is the case for the “nutrient stream” along the Gulf Stream. We aim to ascertain the structure of nutrient concentration enhancement along the Kuroshio jet and to estimate the impact of nutrient transport downstream to the Kuroshio-Oyashio interfrontal zone (KOIZ), which is a highly productive region and a major global fishing ground. Recent multiple- transects and retrospective analyses of historic hydrographic data have revealed that the along-jet maximum nitrate concentration appears only in spring on the isopycnal surface $25<\sigma_\theta<26$ in the downstream region of the Kuroshio. The Kuroshio nutrient stream contributes significantly to productivity in the euphotic layer along its downstream trajectory, in conjunction with enhanced vertical turbulence. Analysis of the budget of epipycnal nitrate transport across transects that enclosed the KOIZ suggests that the Kuroshio nutrient stream has a non-negligible potential to significantly impact high productivity in the KOIZ.

Keywords: Kuroshio nutrient stream, Kuroshio-Oyashio interfrontal zone, epipycnal transport

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Enhanced nutrient supply and biogeochemical impacts induced by internal waves in the oligotrophic northern South China Sea

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To understand nutrient supply and the biogeochemical response induced by internal waves in the deep basin of the northern South China Sea (NSCS), nitrate, chlorophyll *a* (Chl *a*), particulate organic carbon (POC) fluxes were measured during the passage of large internal waves using drifting sediment traps attached with hydrographic sensors. Results revealed large variations in temperature, nitrate and chlorophyll *a* (Chl *a*) concentrations during and after internal waves, suggesting that cold nutrient-replete waters may be brought to the euphotic zone in the dissipation zone during and after the passage of internal wave packets, resulted in phytoplankton flourished in oligotrophic water. The result reveals that ocean mixing triggered by internal waves in warm water of the NSCS may be important for phytoplankton species composition. Most importantly, POC fluxes (110.9±10.7 mg C m^{-2} d^{-1}) were significantly enhanced after internal waves compared to non-internal wave area (32.6–73.0 mg C m^{-2} d^{-1}) in the NSCS. Such elevated POC fluxes may be induced by downward flourished biogenic particles, particle aggregation or converged particles from mixed layer triggered by internal waves.

Keywords: internal waves, ocean mixing, South China Sea, nutrient dynamics

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Mixing over the eastern ridge in the Luzon Strait caused by high-mode internal waves

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The Luzon Strait has two parallel ridges running from north to south, which is known to create large amplitude internal tides. To investigate the mixing processes accompanied by the internal tides, we carried out repeated observations with XBT, XCTD, CTD, and ADCP in the cruise of R/V Hakuho-maru KH-17-5, Leg-2, in November 2017 as part of the OMIX project. We obtained 6 cross sections around the eastern ridge between 121° 30’ E and 122° 10’ E along the line of 21° N.

The cross sections showed wavy structures of isopycnals over the ridge, with 4-7 km of horizontal scale and about 50 m of vertical scale. Velocity distributions by the shipboard ADCP showed strong vertical shear over the ridge, suggesting high-mode internal waves. Froude number of the high-mode internal waves exceeds unity around two summits of the ridge during the periods of strong tidal flow. This suggests that the high-mode internal waves stay over the ridge.

Many temperature inversions, especially large inversions ($\theta > 0.05$ °C) were formed near the ridge (figure). Therefore, energy dissipation rate and vertical diffusivity assuming the model of Osborn (1980) were estimated by calculating Thorpe scale from the temperature profiles. Relatively large energy dissipation rate and vertical diffusivity were distributed over the ridge from surface to the bottom, as well as unstable regions of $Ri < 0.25$. These results reflect strong mixing over the ridge due to the high-mode internal waves.

Keywords: internal waves, Luzon Strait

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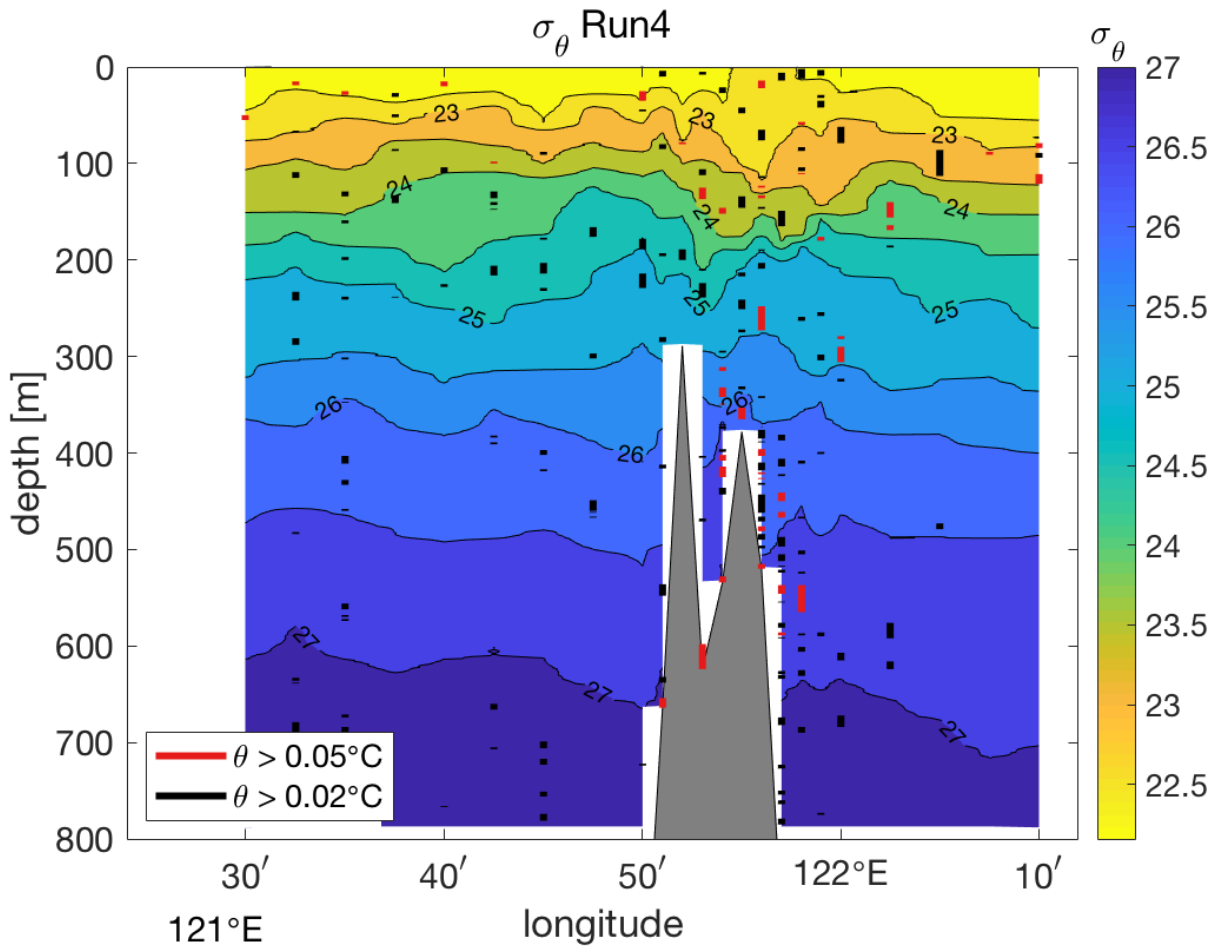

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From the Luzon Strait to the Tsushima Strait: Water masses and nutrient transports approached using ^{137}Cs

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More than 95% of the water flowing into the Sea of Japan comes from the Tsushima Strait, and 80% of it is Kuroshio Intimidate Water (KIW), which is rich in nutrients compared with Kuroshio surface Water and Kuroshio Tropical Water. However, there is a lack of direct evidence based on surveys or measurement data. ^{137}Cs in the subtropical mode water (STMW) that originated in the Fukushima Dai-ichi Nuclear Power Plant (FNPP1) accident is an excellent tracer which can be transported from the Kuroshio upstream to the Sea of Japan crossing the shelf edge of the East China Sea (ECS) via the KIW. It is also useful for research on the transport of nutrients from the KIW.

Data and water samples were collected during the Hakuho-Maru KH-17-5 Cruise and the Nagasaki-Maru 464 Cruise in November and July 2017, respectively. Data from the KH-17-5 Cruise was used for the study of the area around the Luzon Strait and those of the Nagasaki-maru 464 Cruise was used for the study of area around the outer shelf region of the East China Sea and the Tsushima Strait. The ^{137}Cs active concentration was analyzed by γ-Ray spectrometry after preconcentration. The turbulence intensity was measured using TurboMAP and VMP2000.

The maximum ^{137}Cs concentration shows the existence of the subtropical mode water (STMW) in the Luzon Strait, the ECS and the Tsushima Strait, respectively, at the similar density (25.2-25.7 kg/m^3), temperature (15-17℃) and salinity (34.60-34.75). Although their depth changes from 400 m in the Luzon Strait to 150 m at the shelf edge of the ECS and 100m in the East Channel of the Tsushima Strait, they can all be identified as the KIW because of the similar density. It is noteworthy that around Luzon Strait, the distribution of ^{137}Cs is influenced by strong vertical mixing. The percentage of nutrients transported to the Sea of Japan by KIW is estimated and this is meaningful to the ecosystem of the Sea of Japan.

Keywords: 137Cs, subtropical mode water, water masses, KIW, nutrients

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Impact of cyclonic eddies and typhoons on biogeochemistry in the oligotrophic ocean based on time-series observation at the western Pacific subtropical station KEO

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In 2014, a sediment trap mooring experiment started adjacent to station Kuroshio Extension Observatory (KEO)' s National Ocean and Atmosphere Administration (NOAA) surface mooring. Two-years long sediment trap data show that biogenic material fluxes at ~ 5000 m increased between late winter (March) and late spring (June). Based on sea surface temperature and upper ocean water temperature profiles, from the NOAA surface buoy, and satellite-based surface chlorophyll-a , this increase was likely due to an increase of ocean productivity in early spring (March) that was supported by nutrients supplied by winter mixing. On the other hand, biogenic material fluxes also increased in October 2014, and between late December 2014 and January 2015 when concentrations of nutrients near the surface typically are low. Sea surface height anomalies and vertical profiles of water temperature in the upper 500 m showed cyclonic eddies passing station KEO and causing upwelling of middle-layer water in late July–early August 2014 and November 2014. It appears that these events supplied nutrients to the upper layer, which then caused ocean productivity in the subsurface layer to temporally increase, resulting in increased deep biogenic material fluxes in autumn and winter. This interpretation of the data is consistent with a simple 3D physical-biological model simulation that shows meso-scale cyclonic eddies can supply nutrient to support new production at KEO. During the 2-year-long sediment trap deployments, several typhoons also passed near station KEO and near-inertial internal waves were observed near the nitracline depth after the typhoons passed. Although turbulent mixing caused by near-inertial internal wave could have possibly supplied nutrient to upper oligotrophic euphotic layer, numerical simulations of the turbulent nutrient supply indicate that enhanced turbulent diffusion across the nutrient concentration gradient did not supply enough nitrate to support the increase in biogenic material flux in autumn.

Keywords: KEO, Oligotrophic, Sediment trap, Cyclonic eddy, Nutrient, Typhoon

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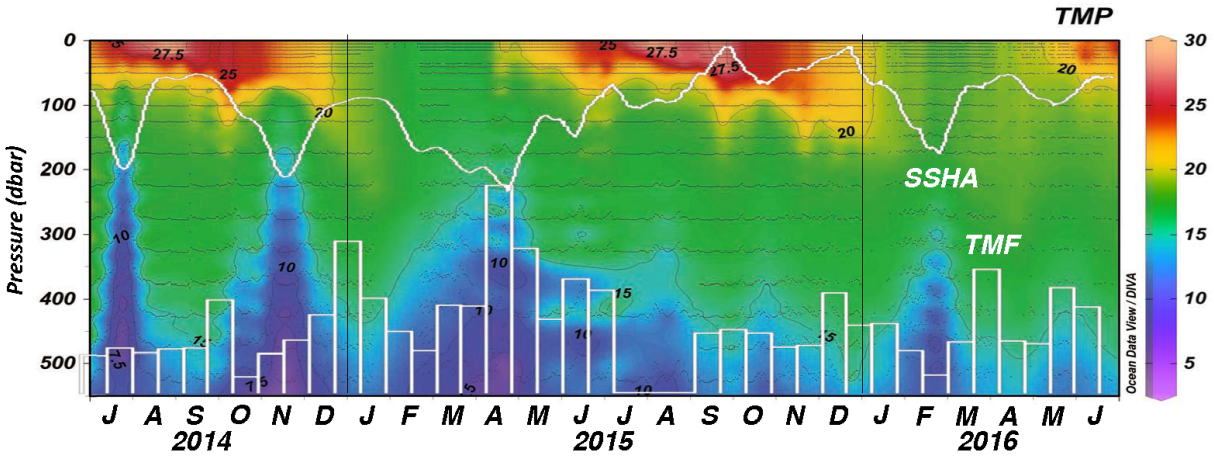

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Island-mass effect on the phytoplankton and zooplankton community in south of Japan

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1. Japan Fisheries Research and Education Agency

The Izu Ridge brings high plankton production via its island-mass effect, which brings up subsurface nutrients to surface layer. Previous reports on island-mass effect around the ridge have been based on observation in the summer-early autumn and reports in spring, when many small pelagic fish species spawn, are scarce. As the Kuroshio flow through the ridge, island-mass effect on zooplankton, which takes more time to glow than phytoplankton, should be appear in eastern (downstream) area. Thus wider area around the ridge should be examined for the effect on zooplankton. In the present study, we examined island-mass effect of the Izu-Ridge on phytoplankton and zooplankton, based on satellite data and zooplankton data in the broad area south of the Honshu.
The Sea surface chlorophyll concentration (SSChl, MODIS-Aqua) in the area bounded by 135.5-142.0 E and 30.0-37.0 N was examined for the grids with depths of > 500 m. Zooplankton samples were collected by vertical tow (0-150 m) of the NORPAC net with 0.335 mm mesh in the area south of Honshu in February to March of 1963-2017. Samples were fixed in 5% formalin-sea water and copepod biomass was estimated in the laboratory by Bench-top Video Plankton Recorder. The relationships between plankton biomass and distance to the Honshu coast and to the Izu Ridge were examined.
The SSChl declined as distance to the Honshu coast increased. But high SSChl was observed in several areas 150-250 km away to the coast. These areas were mainly located around the Izu Ridge, 32-33.5N, and interpreted as caused by island-mass effect when the Kuroshio flowed in offshore path. The copepod biomass was high around the Honshu coast (<50 km). Stations with high copepod biomass were observed in the 100-200 km north-east (downstream) of the Izu Ridge, but they were located near the Honshu, around the Boso peninsula. Island-mass effect of the Izu-ridge on zooplankton biomass thus cannot be distinguished from the coastal effect and the effect should be examined by rate process (spawning rate and/or growth rate) in species level.

Keywords: zooplankton, island-mass effect

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Influence of enhanced deep circulation due to geothermal heat on biogeochemical cycle in the Pacific Ocean

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There exists heat conduction from the oceanic lithosphere to the abyssal ocean. Its heat flux amounts to about 0.1 W m^{-2} in the global average. It is much smaller than the heat exchange between the atmosphere and ocean in the order of 10 W m^{-2}. However, it is known that this geothermal heat significantly enhances the deep circulation especially in the Pacific Ocean. For example, Adcroft et al. (2001) conduct numerical experiments with/without geothermal heating using an ocean general circulation model and report that constant heat flux at the sea bottom by 0.05 W m^{-2} results in enhancement of the Pacific meridional overturning circulation (PMOC) by 25 %. Other studies also report that the geothermal heat significantly enhances the oceanic deep circulation (e.g., Emile-Geay and Madec, 2009; Urakawa and Hasumi, 2009; Downes et al., 2016). The importance of the geothermal heat seems to be robust from the viewpoint of ocean dynamics but it has not been investigated to what extent the geothermal heat influences the biogeochemical cycle of the ocean. Here, we conduct two numerical experiments with/without the geothermal heat using an ocean general circulation model developed for the CMIP6 and investigate the effect of the geothermal heat on the biogeochemical tracer fields.
The geothermal heating enhances PMOC at 30º S by 17 % in this model, which leads to stronger ventilation in the North Pacific Ocean. This stronger ventilation results in increase of delta ^{14}C by more than 10 per mille, which means younger water masses, at the bottom of the North Pacific. The stronger PMOC also results in higher dissolved oxygen in the abyss especially in the eastern tropical Pacific. The geothermal heat leads to dissolved oxygen increase by more than 10 micro mol L^{-1} there, which corresponds to 10–70 % of hypoxic water in the control experiment without geothermal heating. This oxygenation near the sea bottom affects the oxygen-deficient water in the surface of the eastern tropical Pacific. Its thickness becomes thinner by around 100 m. The geothermal heat also plays an important role in the biogeochemical cycle in the Pacific Ocean.

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The Parameterization of the Pressure-Strain Correlations in the Stably or Unstably Stratified Ocean Surface Layer.

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1. Graduate School of Science, Kyoto University

Turbulence in the ocean surface layer mixes momentum, heat, and nutrient vertically. It is therefore important for air-sea interaction, phytoplankton blooming, and other oceanic processes (e.g., Roxy et al. 2013; Obata et al. 1996). However, large-scale models such as ocean general circulation models cannot explicitly resolve small-scale turbulence because of their coarse resolution. For this reason, the vertical mixing should be parameterized using the turbulent closure scheme that successfully parameterizes the turbulent mixing. Recently, attention is paid to pressure-strain correlations, which redistribute stress due to fluctuating pressure, in the parameterization scheme used for engineering purposes (Jakilic and Hanjalic 2013). In the present study, therefore, the validity of the pressure-strain correlation parameterization used in the ocean (or atmosphere) (Rotta 1951, Gibson and Launder 1978, Gertski et al. 1992) was examined. To this end, we performed Large-eddy simulations of ocean surface boundary layer to simulate pressure-strain correlations and compared it with parameterized correlations. Here, we focused on the effects of stratification on the correlations, because the stratification is an essential factor in the ocean and atmospheric boundary layers but previous schemes did not include the stratification effects sufficiently. Results show that the parameterizations of the pressure-strain correlations had systematic errors depending on the stability (or stratification). It was also found that the error can be reduced by introducing new parameters related to the stability into the scheme.

Keywords: Parameterization of Pressure-Strain Correlations, Turbulent Closure Model, Turbulence in the Ocean Surface Layer

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Numerical studies on asymmetric responses of the upper ocean to tropical cyclone

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1. Graduate School of Science, Kyoto University

Tropical cyclones (TCs) decrease sea surface temperature (SST), and the decreased SST weakens TC intensity. This SST decrease is asymmetric with respect to the TC track, known as “rightward bias”. Preceding numerical studies suggested that this asymmetry may influence on the course of the TC. The interaction between TC and the upper ocean is one of key ingredients for precisely predicting TC's development, and the upper ocean response to TC should also be clarified.
The SST decrease during TC passage is mainly caused by two processes; vertical turbulent mixing and advection (Ekman suction). The rightward bias is associated with the mixing which is more intense on the right side of the TC track due to resonant inertial currents with winds. Magnitude and distribution of SST decrease induced by the mixing should vary with parameters characterizing TC; transition speed U_T, radius of maximum wind R_{max}, the friction velocity U_*, and the Coriolis coefficient f. However, detailed physical processes of the mixing and its dependence on these parameters have not been well quantified, because of lack of in-situ data and complicated processes involved in the mixing.

The present study focuses on the vertical turbulent mixing effects on asymmetric SST response. To this aim, vertically one-dimensional model was used in which the vertical turbulent mixing was parameterized with the Nakanishi-Niino-Mellor-Yamada scheme modified by Kitamura (2010). We considered TC-like wind stress of magnitude U_*^2 at radius R_{max} from the TC center moving with transition speed U_T and investigated the mixing on both sides of TC track at distance *r*. Experiments with several friction velocities U_*, maximum wind radii R_{max}, transition speeds U_T and distances *r* were performed. No surface heat flux was considered for simplicity.
The results showed that the rightward bias of the SST response depended on these parameters. The location of the largest SST decrease moved away from the axis as U_T increased, but it depended less on U_*. The SST decreased more with larger U_* and smaller U_T. These results can be explained by energy flux at the surface. In our model configuration, the energy flux depends on two non-dimensional parameters, U_T/fR_{max} and U_*/U_T, and the energy flux had maximum and turbulent kinetic energy penetrated deeper at larger U_*/U_T and at U_T/fR_{max}~1, suggesting the resonance between wind and the inertial current. The SST decrease corresponded with the energy flux, but it depended largely on U_*/U_T, implying importance of wind forcing duration.
Thus, the asymmetric SST response due to the vertical turbulent mixing can be characterized with U_T/fR_{max} and U_*/U_T. Additional advection effects on the SST response will be discussed at the conference using three-dimensional simulation in which the advection as well as the mixing are fully included.

Keywords: Tropical cyclone, Vertical turbulent mixing, Ekman suction, Rightward bias

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Influence of the distortion of the internal wave field on estimates of turbulent mixing using fine-scale parameterizations

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1. Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo, 2. National Oceanography Centre, University of Southampton

Although the Southern Ocean is one of the turbulent mixing hotspots, we have not yet clarified quantitatively the turbulent mixing processes in this region, where the Antarctic Circumpolar Current (ACC) coexists with near-inertial internal waves generated by wind forcing and internal lee waves radiated by the impingement of eddy flows on topography.

Fine-scale parameterizations, based on the theory of energy cascade from internal waves to turbulence, are most widely used to estimate the turbulent dissipation rate, ε. It has been reported, however, that these fine-scale parameterizations tend to overestimate ε in the ACC (Waterman et al. 2014). Although Takahashi and Hibiya (2019) have suggested that "the distorted fine-scale shear and strain spectra" caused by the existence of eddies trapping near-inertial waves or upward-propagating internal lee waves might be responsible for the overestimates, the problem remains unresolved.

In this study, we use "eikonal" simulations (Henyey et al. 1986), which trace the propagation, refraction and breaking of test waves within a background internal wave field, to assess the evolution of the energy cascade in vertical wavenumber space. Our objective is to examine how the distortion of the vertical wavenumber spectrum affects the performance of fine-scale parameterizations.

In our simulations, in contrast to high vertical wavenumber test waves that are efficiently Doppler-shifted to their breaking limit, low vertical wavenumber test waves are not subject to dissipation processes. In the existing fine-scale parameterizations, however, the energy flux to dissipation scale is estimated using the integrated vertical wavenumber spectral values. This means that, if the range of this integration includes a spectral bump at the low-wavenumber end of the spectrum, the estimated energy flux and hence the resulting ε might be overestimated by these fine-scale parameterizations.

From the simulation results, it is confirmed that fine-scale parameterizations significantly overestimate ε in spectra with a low-wavenumber bump, in particular as the internal wave energy level becomes large and the shear/strain ratio becomes small. These results are supported by the microstructure and fine-structure dataset from the SOFine experiment carried out in the Kerguelen Plateau.

Keywords: Turbulent Mixing, Fine-scale parameterizations, Antarctic Circumpolar Current region

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_3

[A-OS21] Physical, biogeochemical, and ecological aspects and their mutual relations in the Indian Ocean

convener:Yukio Masumoto(Graduate School of Science, The University of Tokyo), Hiroaki Saito(Atmosphere and Ocean Research Institute, The University of Tokyo), Iwao Ueki(JAMSTEC Japan Agency for Marine-Earth Science and Technology)

Recent discovery of new climate modes and development of basin-scale and regional
observing systems in the Indian Ocean advance researches on physical, biogeochemical,
and ecological aspects of ocean variations. In addition, international and interdisciplinary
research programs in the Indian Ocean, such as IIOE-2 and EIOURI, are now being
conducted in earnest, under which the R/V Hakuho-maru cruise in the eastern Indian
Ocean will be took place in Nov./Dec. 2018, for better understanding of eastern Indian
Ocean conditions through multi-disciplinary approaches. This session invites papers on
physical, biogeochemical, and ecological aspects in the Indian Ocean and relations
among these elements of the ocean variations, to facilitate integrated understanding of
the Indian Ocean variability, as well as to stimulate collaborative researches among the
relevant scientists. Preliminary results from observation campaigns, a new perspective
on research collaboration, and/or sharing information on future observing activities are
also welcome.

[AOS21-P01] **Freshening of Indonesian Upper Water and Salinification of Indonesian Intermediate Water in the Indian Ocean during the last decade**

*ISKANDAR MOCHAMAD RIZA[1], Toshio Suga[1] (1.Graduate School of Sciences, Tohoku University)

[AOS21-P02] Characteristics in the upper ocean physical properties associated with 2018 Ningaloo Nina observed during R/V Hakuho-Maru KH-18-6 cruise

*Yukio Masumoto[1], Iwao Ueki[2], Kentaro Ando[2], Takanori Horii[2], Motoki Nagura[2], Shuhei Matsugishi[1], Shoichiro Kido[1], Takuro Matsuta[1] (1.Graduate School of Science, The University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology)

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1. Graduate School of Sciences, Tohoku University

The Indonesian region, also known as a central part of the “Maritime Continent” is located at the tropical region between the Pacific Ocean and the Indian Ocean. The water in Indonesian seas mostly consists of North Pacific waters (North Pacific Intermediate Water, NPIW and North Pacific Subtropical Water, NPSW) with the small fraction of South Pacific waters (South Pacific Intermediate Water, SPIW and South Pacific Subtropical Water, SPSW). During transit through the Indonesian seas, the saltier NPSW is modified due to atmospheric and oceanic forcing, i.e., evaporation/precipitation and tidal mixing, becoming fresher water.

The water from Indonesian seas can be distinguished in the Indian Ocean as low salinity water from the surface to the thermocline, called with Indonesian Throughflow water (ITW) or Indonesian Upper Water (IUW) and intermediate low salinity water known as Banda Seawater (BSW) or Indonesian Intermediate Water (IIW). Temporal variations of properties of these water masses in the South Eastern Indian Ocean over the last decade is investigated by using the gridded monthly mean of Argo dataset, MOAA-GPV and profile dataset in World Ocean Database (WOD). The freshening trend of the Indonesian Upper Water (IUW, 23 $\sigma\ \theta$) and salinification trend of the Indonesian Intermediate Water (IIW, 27.3 $\sigma\ \theta$) are detected. These trends are opposite with the salinification trend of North Pacific Subtropical Water (NPSW) and freshening trend of North Pacific Intermediate Water (NPIW) in the Pacific inflow region of ITF. The opposite trends between the inflow and outflow of ITF are at least partly explained as follows.

The freshening in the IUW is consistent with the low E-P within Indonesia region. High freshwater input in the Indonesian Seas from E-P on the last decade was proposed as one of the contributors to the freshening of IUW. Using simple Lagrangian estimation, as much as one to two third freshening are coming from this freshwater input. The salinification of IIW is drawn roughly by vertical salinity convergence due to vertical mixing between the top (400m) and bottom (1200m) of the intermediate layer. The enhanced vertical mixing due to salinification of water just above IIW is proposed as a major contributor to the salinification of IIW.

Keywords: Indonesian Seas, Indonesian Upper Water, Indonesian Intermediate Water

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1. Graduate School of Science, The University of Tokyo, 2. Japan Agency for Marine-Earth Science and Technology

R/V Hakuho-maru cruise, KH-18-6 Leg3, was conducted in December 2018 in a region between Indonesia and Australia. A relatively strong Ningaloo Nina took place during the cruise, showing negative sea surface temperature anomaly of the order of few degrees with strong southerly surface winds off northwest Australia. This presentation summarizes subsurface physical conditions observed during the cruise on a rare occasion, focusing on anomalies associated with the Ningaloo Nina and their relation with a large scale circulations and variations.

Keywords: Ningaloo Nina, Observation of physical conditions in the ocean, R/V Hakuho-Maru observation cruise

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_12

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Characteristics in the upper ocean physical properties associated with 2018 Ningaloo Nina observed during R/V Hakuho-Maru KH-18-6 cruise

*Yukio Masumoto[1], Iwao Ueki[2], Kentaro Ando[2], Takanori Horii[2], Motoki Nagura[2], Shuhei Matsugishi[1], Shoichiro Kido[1], Takuro Matsuta[1]

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R/V Hakuho-maru cruise, KH-18-6 Leg3, was conducted in December 2018 in a region between Indonesia and Australia. A relatively strong Ningaloo Nina took place during the cruise, showing negative sea surface temperature anomaly of the order of few degrees with strong southerly surface winds off northwest Australia. This presentation summarizes subsurface physical conditions observed during the cruise on a rare occasion, focusing on anomalies associated with the Ningaloo Nina and their relation with a large scale circulations and variations.

Keywords: Ningaloo Nina, Observation of physical conditions in the ocean, R/V Hakuho-Maru observation cruise

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-OS Ocean Sciences & Ocean Environment

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 303 3F

[A-OS21] Physical, biogeochemical, and ecological aspects and their mutual relations in the Indian Ocean

convener:Yukio Masumoto(Graduate School of Science, The University of Tokyo), Hiroaki Saito(Atmosphere and Ocean Research Institute, The University of Tokyo), Iwao Ueki(JAMSTEC Japan Agency for Marine-Earth Science and Technology), Chairperson:Yukio Masumoto

Recent discovery of new climate modes and development of basin-scale and regional
observing systems in the Indian Ocean advance researches on physical, biogeochemical,
and ecological aspects of ocean variations. In addition, international and interdisciplinary
research programs in the Indian Ocean, such as IIOE-2 and EIOURI, are now being
conducted in earnest, under which the R/V Hakuho-maru cruise in the eastern Indian
Ocean will be took place in Nov./Dec. 2018, for better understanding of eastern Indian
Ocean conditions through multi-disciplinary approaches. This session invites papers on
physical, biogeochemical, and ecological aspects in the Indian Ocean and relations
among these elements of the ocean variations, to facilitate integrated understanding of
the Indian Ocean variability, as well as to stimulate collaborative researches among the
relevant scientists. Preliminary results from observation campaigns, a new perspective
on research collaboration, and/or sharing information on future observing activities are
also welcome.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[AOS21-01] Coastal upwelling events and barrier layer observed along the southwestern coast of Sumatra

*Takanori Horii[1], Iwao Ueki[1], Kentaro Ando[1] (1.Research and Development Center for Global Change (RCGC), Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[AOS21-02] Mechanisms of the sea surface temperature cooling in the Somalia-Oman upwelling region during the summer monsoon

*Kusumi Takahiro[1], Shoichiro Kido[1], Tomoki Tozuka[1], Yukio Masumoto[1] (1.the Unversity of Tokyo)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[AOS21-03] Generation of meso-scale eddies in the southern Indian ocean

*Takuro Matsuta[1], Yukio Masumoto[1] (1.Graduate School of Science, The University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[AOS21-04] Summary of R/V Hakuho-Maru observations (KH-18-6) for Integrated physical, biogeochemical, and ecosystem research in the eastern Indian Ocean

*Yukio Masumoto[1], Hiroaki Saito[2] (1.Graduate School of Science, The University of Tokyo, 2.Atmosphere and Ocean Research Institute)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[AOS21-05] Distribution and photodegradation of fluorescent dissolved organic matter in the eastern Indian Ocean

*Shigenobu Takeda[1] (1.Nagasaki University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[AOS21-06] Observed subsurface Chlorophyll maximum in the tropical eastern Indian Ocean during KH18-6 Leg3 cruise

*Iwao Ueki[1], Kosei Sasaoka[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology)

Coastal upwelling events and barrier layer observed along the southwestern coast of Sumatra

*Takanori Horii[1], Iwao Ueki[1], Kentaro Ando[1]

1. Research and Development Center for Global Change (RCGC), Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

Coastal upwelling along the southwestern coast of Sumatra during the boreal summer monsoon is closely linked to the El Nino/Southern Oscillation and the Indian Ocean Dipole. To understand the coastal upwelling system, we investigated ocean temperature and salinity variations obtained from Argo floats. During 2013-2017, two Argo floats observed vertical structure of temperature and salinity every 10 days within 100 km from the coast of Sumatra. The floats observed intraseasonal-scale subsurface temperature cooling events with significant upward movements of thermocline. Anomalous local southwesterly winds and equatorial easterly winds explained the temperature cooling and thermocline variations, suggesting that the Argo observation captured coastal upwelling signal. Although these subsurface temperature cooling signals were significant, local sea surface temperature (SST) variations were relatively small. We found that during coastal upwelling events, local SST tended to be disconnected with subsurface cooling by the presence of upper-layer salinity stratification and thick barrier layer which suppressed entrainment cooling.

Keywords: Coastal upwelling, Sumatra, Barrier layer, Indian Ocean Dipole

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Mechanisms of the sea surface temperature cooling in the Somalia-Oman upwelling region during the summer monsoon

*Kusumi Takahiro[1], Shoichiro Kido[1], Tomoki Tozuka[1], Yukio Masumoto[1]

1. the Unversity of Tokyo

Alongshore southwesterly winds in the western Arabian Sea associated with the Indian summer monsoon induce coastal upwelling and cool sea surface temperature (SST) along the coast of Somalia and Oman. Since the upwelling region is a moisture source of the Indian summer monsoon rainfall, understanding of the SST variations in this region is crucial for the prediction of the Indian summer monsoon precipitation. In this study, an on-line mixed layer heat budget analysis is conducted to clarify the mechanisms of the SST cooling using the Regional Ocean Modeling System (ROMS) simulation. It is revealed that causes of the SST cooling in the upwelling region are different between the onset (May) and mature phases (June-July) of the Indian summer monsoon. The horizontal advection, surface heat flux, entrainment and vertical diffusion terms contribute to the cooling in the former phase, while the vertical diffusion term plays a dominant role in the latter phase.

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Generation of meso-scale eddies in the southern Indian ocean

*Takuro Matsuta[1], Yukio Masumoto[1]

1. Graduate School of Science, The University of Tokyo

A Leeuwin Current region off the coast of western Australia is known as an area of strong meso-scale eddy activity among the midlatitude eastern boundary current regions. While these eddies are believed to be generated through mixed barotropic and baroclinic instability associated with the poleward-flowing Leeuwin Current, their relative importance as well as interactions between eddies and large-scale circulations need to be investigated in detail. Motivated by the above, an analysis on energy conversion between eddy field and mean flow is conducted. Results revealed detailed spatial distributions of large baroclinic energy conversion. The interactions between density anomalies and the thermal front near 30˚ S play an important role in making the baroclinic energy conversion.

Keywords: meso-scale eddies, Leeuwin Current, eddy-mean flow interactions

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Summary of R/V Hakuho-Maru observations (KH-18-6) for Integrated physical, biogeochemical, and ecosystem research in the eastern Indian Ocean

*Yukio Masumoto[1], Hiroaki Saito[2]

1. Graduate School of Science, The University of Tokyo, 2. Atmosphere and Ocean Research Institute

R/V Hakuho-Maru cruise (KH-18-6) was conducted from Nov. 6 (leaving from Phuket) to Dec. 29 (Arriving at Fremantle) to facilitate integrated physical, biogeochemical, and ecosystem researches in the eastern Indian Ocean, which is a core research project under EIOURI and IIOE-2. The first leg occupied the 88E section from the Bay of Bengal down to 20S, while the second leg observed the region between the Java Island and northwestern Australia. During these legs, measurements of physical, chemical, biological, and ecological parameters were taken place by multiple equipment such as CTD casts, water sampling, LADCP, net observations, turbulence measurements. This presentation introduce summary of observations conducted during the cruise and highlights some preliminary results, together with the basic conditions during the observations.

Keywords: Eastern Indian Ocean, Observations

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Distribution and photodegradation of fluorescent dissolved organic matter in the eastern Indian Ocean

*Shigenobu Takeda[1]

1. Nagasaki University

Dissolved organic matter (DOM) is one of the major carbon reservoirs in the ocean, and a fraction of DOM fluoresces blue light when excited by UV light. Two main components of fluorescent dissolved organic matter (FDOM) are protein- and humic-like fluorophores. The environmental dynamics of FDOM in the open ocean has been reported to include photodegradation at surface layers and production through microbial decomposition of organic matters in deeper layers. Humic-like FDOM may playing a role as natural organic ligands for several dissolved trace metals such as iron in intermediate and deep waters, and therefore studies on the distribution and dynamics of FDOM are also important for better understandings of trace-metal cycles in the ocean.

During a KH-18-6 cruise by the R/V Hakuho-maru in November 2018, observations were conducted along a transect at 88ºE in the eastern Indian Ocean, where changes in biological activities of organic matter production and decomposition are remarkable in the north-south direction. Vertical distributions of FDOM fluorescence intensity were obtained at 9 stations along the transect from 16.5ºN to 20ºS. Seawater samples collected using Niskin-X bottles on a CTD-Carousel system were filtered through a filter unit having 0.2 μm pore-size and fluorescence intensity of FDOM was measured onboard by Trilogy Laboratory Fluorometer (Turner Designs) equipped with UV module (7200-067W, Excitation 350/80 nm; Emission 410-450 nm) using the 4 ppb quinine sulfate solution as a standard. In order to evaluate photodegradation of FDOM, selected filtered seawater samples were placed in 500 ml quartz bottles and these bottles were exposed to sunlight in an on-deck running seawater tank. Changes in fluorescent intensity of FDOM were monitored every 24 hours for 5 days.

The vertical distributions of FDOM fluorescence intensity showed nutrient-type profile; very low values at the surface, enrichment at intermediate depth, and gradual decrease in deep layers. A distinct peak of fluorescence intensity was also observed at the oxygen minimum layer just below the subsurface chlorophyll maximum. Along the N-S transect, fluorescence intensity of FDOM in the water column was highest at 15ºN in the Bay of Bengal, and there was a decreasing trend to the southward direction. The FDOM fluorescence intensity generally correlated with apparent oxygen utilization (AOU) in the intermediate and deep layers. However, high fluorescence intensities deviate from the FDOM-AOU relationship were measured below the subsurface chlorophyll maximum layer in the Bay of Bengal, suggesting that characteristics of fluorophores produced by microbial decomposition of organic matters might varies depending on the depth and area of the sea. In the solar irradiation experiments, a significant photobleaching was observed within 24 hours followed by gradual decrease in FDOM fluorescence intensity during the remaining period of the experiments. It indicate the existence of fluorophores having different photolability in the FDOM. One of the experiments also showed control of FDOM photodegradation by the irradiation level. These results suggest that light field and vertical mixing process near the sea surface as well as vertical difference in quality and quantity of organic matter for decomposition by diverse microbial community could have a strong influences on dynamics of FDOM in the eastern Indian Ocean.

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Keywords: Indian Ocean, FDOM, Photodegradation

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Observed subsurface Chlorophyll maximum in the tropical eastern Indian Ocean during KH18-6 Leg3 cruise

*Iwao Ueki[1], Kosei Sasaoka[1]

1. JAMSTEC Japan Agency for Marine-Earth Science and Technology

To enhance interdisciplinary understanding of the eastern Indian Ocean upwelling study, R/V Hakuho-Maru KH18-6 cruise has been conducted in November-December 2018. During the Leg-3 cruise; started from Jakarta in 06 December and arrived at Fremantle in 29 December, physical, chemical and biogeochemical observations at more than 30 stations along 3 sections have been conducted. During the Leg 3 cruise, climate condition of the Indian Ocean became a neutral condition after positive Indian Ocean Dipole event. At the eastern section from the station 22 (12°S, 112.5°E) to station 34 (24°S, 111° E), we can capture predominance of eddy activity at around 16°S. In terms of chlorophyll distribution, subsurface maximum were recognized at the all stations. However, the distribution was modified in associated with the eddy activity. The details will be shown in the presentation.

Keywords: The eastern Indian Ocean, Chlorophyll, Eddy

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[J] Oral | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 301A 3F

[A-CG43] Adaptation for climate change and social implementation

convener:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience), Chairperson:KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience), Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology)

Adaptation for climate change is urgent issue since increasing risk of natural disaster, such as typhoon and heavy rain and harmful effect of high temperature on agriculture are expected. "Climate change adaptation law" has passed the National Diet in 2018, in which the vision are given to build a secure, safe and sustainable society that is able to minimizing and avoiding damage. These actions to formulate the adaptation plan are expected to rapidly spread for local governments.
For this purpose, simulation of climate change projection, downscaling technique to obtain the detailed estimation of climate change in local scale, the evaluation of risk to contribute the formulation of adaptation plan are necessary, as well as the issue for social implementation such as co-design working with stakeholders.
We will discuss the current status of the simulation modeling and knowledge gap between the scientists and stakeholders.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[ACG43-01] **Effects of afforestation and climate warming on evapotranspiration and river discharge in the upper Chao Phraya River basin**

*Kumiko TAKATA[1], Naota Hanasaki[1] (1.National Institute for Environmental Studies)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[ACG43-02] Hybrid downscaling using high-resolution RCM information and rainfall-runoff-inundation model simulations

*Yasutaka Wakazuki[1,2], Shiori Abe[4], Yosuke Nakamura[3,4] (1.Ibaraki University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Public Works Research Institute, 4.Mitsui Consultants Co., Ltd.)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[ACG43-03] Development of a global water risk assessment tool to support investigation of adaptation to climate change in the private sector: Calibrating parameters of a global water resources model by Approximate Bayesian Computation

*Naota Hanasaki[1] (1.NIES National Institute of Environmental Studies)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[ACG43-04] Verification of SI-CAT ocean products around Japan

*Goro Yamanaka[1], Hideyuki Nakano[1], Kei Sakamoto[1], Takahiro Toyoda[1], Shogo Urakawa[1], Hiroyuki Tsujino[1], Shiro Nishikawa[2], Tsuyoshi Wakamatsu[2,3,4], Yoichi Ishikawa[2] (1.Meteorological Research Institute, 2.JAMSTEC, 3.Nansen Environmental and Remote Sensing Center, 4.Bjerknes Centre for Climate Research)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[ACG43-05] Downscaling and Reanalysis of Coastal Current System on the Ibaraki Coast with Included Freshwater Impact

*Josko Troselj[1], Yuki Imai[2], Junichi Ninomiya[3], Nobuhito Mori[1] (1.Coastal Engineering Laboratory, Disaster Prevention Research Institute, Kyoto University, 2.Graduate School of Engineering, Kyoto University, 3.Kanazawa University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[ACG43-06] Estimation of the Japanese sardine stock in relation to the future Kuroshio variability

*Haruka Nishikawa[1], Shiro Nishikawa[1], Tsuyoshi Wakamatsu[2,3], Yoichi Ishikawa[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Nansen Environmental and Remote Sensing Center, 3.Bjerknes Center for Climate Research)

Effects of afforestation and climate warming on evapotranspiration and river discharge in the upper Chao Phraya River basin

*Kumiko TAKATA[1], Naota Hanasaki[1]

1. National Institute for Environmental Studies

In the Chao Phraya River basin (hereafter as CP), deforestation has been proceeding in the upper mountainous regions; and in the uppermost tributary of the Nan River the increasing trend in low flow was observed, that could potentially be related to deforestation in the basin (Tebakari et al., 2018). Besides, runoff in CP is projected to increase under the global warming particularly in the rainy season (Kotsuki et al., 2014), that would enhance the risks of floods which regularly occur in the late rainy season. Since afforestation has effects to decrease the annual runoff and its peak amount, it is considered as an adaptation measure. However, it also has effects to increase evapotranspiration, that would enhance the water scarcity in the dry season.

In this study, offline experiments were conducted with a land surface model, MATSIRO (Takata et al, 2003; Nitta et al., 2014) that explicitly considered the processes of vegetation canopy to examine the effects of afforestation on river discharge and evapotranspiration in the upper CP under a warmed climate. The meteorological conditions for the 20th century (1981-2004; Kotsuki et al., 2013) and the future (2040-2059 and 2080-2099, Watanabe et al., 2014) with two warming scenarios and three climate models were used. Three experiments were conducted at the horizontal resolution of 5 arc-minutes: the first one is with the vegetation distribution in 2000 (control, CTL), the second one is with that in 1970 (AFR20) in which cropland is 20% less than CTL, and the third one is with that in 1950 (AFR100) in which most of the land is covered with natural vegetation (AFR100).

The annual precipitation, runoff, and evapotranspiration were increased by the warming. About 80% of the precipitation increase turned into the runoff increase, and the remaining 20% into evapotranspiration. The annual increase in runoff was reduced by 3-5% with AFR20 and 10-15% with AFR100 in the mid-21st century. The reduction shrinks with the progress of the warming which agrees with the report by Chacuttrikul et al. (2018), though the simplified simulation for changes in soil properties by afforestation suggested an enhancement of the reduction. The runoff reduction by forest-cover increase was due to the enhancement of evapotranspiration increase. Looking into the seasonal pattern of the changes, the runoff increase corresponds to about 75% of the precipitation increase in the rainy season. The evapotranspiration increase in the rainy season was about 10%, and the remaining 15% turned into the evapotranspiration increase in the dry season. In conclusion, the effect of runoff reduction by forest-cover increase was marked in the rainy season, while the effect of evapotranspiration enhancement was marked in the dry season. It is therefore necessary to take note the both effects of runoff reduction in wet season and evapotranspiration enhancement in dry season, in considering afforestation for an adaptation measure for water management issues.

Acknowledgements: This research was supported by Science and Technology Research Partnership for Sustainable Development (SATREPS) program by Japan Science and Technology Agency (JST) and Japan International Cooperation Agency (JICA), and by the Environment Research and Technology Development Fund (S-14-5) of the Environmental Restoration and Conservation Agency.

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Keywords: Afforestation, Runoff, Evapotranspiration, Chao Phraya River basin

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Hybrid downscaling using high-resolution RCM information and rainfall-runoff-inundation model simulations

*Yasutaka Wakazuki[1,2], Shiori Abe[4], Yosuke Nakamura[3,4]

1. Ibaraki University, 2. Japan Agency for Marine-Earth Science and Technology, 3. Public Works Research Institute, 4. Mitsui Consultants Co., Ltd.

The statistical downscaling is calculated with lighter computational costs for various patterns of climate states in future which are needed to estimate uncertainty of regional climate change. However, the estimation accuracy is low in areas of poor observations. On the other hand, dynamical downscaling with high-resolution regional climate model (RCM) use huge computational costs, whereas climatological features are well reproduced even in areas of poor observations. A statistical downscaling method as a hybrid-downscaling making use of the advantage of super high-resolution dynamical downscaling is proposed in previous JPGU annual meeting. In addition, the reproducibility of intense precipitation was improved by introducing a new precipitation correction method applying PDF for hourly precipitation. Downscaling results of climate change projections had been used for simulations of rainfall-runoff-inundation (RRI) model with the target area of Kinu and Kokai river basins, Kanto, Japan. The regional climate projection showed almost 6 % increase of precipitation in the river basins. In a simulation, the yearly maximum of daily precipitation was predicted to increase about 15 %, which is almost the same as the increase rate of yearly maximum of river discharge, 12 %. On the other hand, the increase rate of yearly maximum of peak water level was estimated to be only 1 %. In Japan, several high-risk water levels are configured at observation points. The frequencies of moderate high-risk water levels were projected to significantly increase. On the other hand, the changes in the frequencies of severe high-risk water levels were projected to be small. The small increase rate was due to structure of cross sections of the river and the dam control model. The inundation areas and depths were also calculated. The increase rate of the inundation area was estimated to be about 35 %. The risk of large inundation is regarded to increase in the future climate.

Keywords: Downscaling, Regional climate model, rainfall-runoff-inundation model

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Development of a global water risk assessment tool to support investigation of adaptation to climate change in the private sector: Calibrating parameters of a global water resources model by Approximate Bayesian Computation

*Naota Hanasaki[1]

1. NIES National Institute of Environmental Studies

Private companies need to avoid the harmful impacts on their business and express their plans and actions toward climate change. To support climate change adaptation planning of private sectors, an open global water risk assessment tool is being developed.

The global hydrological model H08 can simulate not only natural hydrological cycle but also human water use simultaneously at a daily interval at a spatial resolution of 0.5 degree. By feeding future climate scenarios and socio-economic assumptions to H08, one can analyze the change in hydrological cycle and water requirement/use due to global change with spatiotemporal details. Although these features are useful to investigate the risks of flood and drought in the future, the uncertainty in the model hampers effective interpretation. In particular, the simulation performance at the places where production bases are located is crucial for private companies. Therefore, parameter calibration was performed which has been seldom carried out at a global scale.

In this study, we applied the Approximate Bayesian Computation (ABC) to calibrate four key hydrological parameters of H08. Altogether 5000 simulations were conducted by changing four parameters randomly. By identifying the range of each parameter that showed the best performance in reproducing the past, we systematically calibrated the ranges of four parameters. This approach was applied for 64 basins with more than 500,000km2 of catchment area in the world. The results showed that calibrated parameters produced reasonable simulation results for most of the basins in the world. In the presentation, the results for smaller catchments and daily simulations will be presented.

Keywords: Adaptation, Climate Change, Water resources

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Verification of SI-CAT ocean products around Japan

*Goro Yamanaka[1], Hideyuki Nakano[1], Kei Sakamoto[1], Takahiro Toyoda[1], Shogo Urakawa[1], Hiroyuki Tsujino[1], Shiro Nishikawa[2], Tsuyoshi Wakamatsu[2,3,4], Yoichi Ishikawa[2]

1. Meteorological Research Institute, 2. JAMSTEC, 3. Nansen Environmental and Remote Sensing Center, 4. Bjerknes Centre for Climate Research

We examined SI-CAT ocean products around Japan, such as sea surface temperature (SST) and sea level, Kuroshio, and sea-ice in the Sea of Okhotsk. We used the SICAT10 Version 2 data, in which the North Pacific Ocean model with a resolution of 10 km was driven by JRA-55 and CMIP5 (MIROC5, MRI-CGCM 3, GFDL-ESM2M, IPSL-CM5A-MR) atmospheric forcing under the present climate (1960-2005). Observation data used for verification are COBE-SST2 and CMEMS. We made a t-test for the mean difference between the observed and simulated fields, as well as a f-test for the ratio of the observed variance to the simulated. The p-value was taken as a measure of the reliability of the model. The simulated SSTs generally capture the dominant low-frequency modes in the North Pacific in each run. In the sea around Japan, the reliability of the variability is relatively high except for the regions where eddy activity is enhanced, such as off the east of Tohoku and off the south of Japan. The regional averaged SSTs show a long-term upward trend as in the observation. Compared to the reliability of the simulated SST, that of the simulated sea level is relatively low, but the average sea level around Japan shows low-frequency variability associated with PDO as well as long-term upward trends related to the global warming. The average Kuroshio flow path and the position of Kuroshio Extension are generally well captured by the 10 km model. The latitudes of the simulated Kuroshio Extension show no remarkable trend like observation. In the Sea of Okhotsk, the simulated sea ice area during the winter is captured in the IPSL run, but is underestimated (overestimated) in the MIROC run (the MRI and GFDL runs). The long-term trend in winter shows a statistically significant decrease in the GFDL run, which is similar to the observation.

Keywords: SI-CAT, climate change adaptation, high-resolution ocean general circulation model

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Downscaling and Reanalysis of Coastal Current System on the Ibaraki Coast with Included Freshwater Impact

*Josko Troselj[1], Yuki Imai[2], Junichi Ninomiya[3], Nobuhito Mori[1]

1. Coastal Engineering Laboratory, Disaster Prevention Research Institute, Kyoto University, 2. Graduate School of Engineering, Kyoto University, 3. Kanazawa University

Introduction and Objective

Global mean sea level, surface temperatures and extreme precipitation amounts are expected to increase in 21st century under the climate change impact. It will especially affect coastal zones which are sensitive to all of these factors because extreme freshwater inflow, inundation levels, erosion as well as fishery industry nearshore are expected to be largely impacted. Coastal processes, such as variabilities of shallow water temperatures, cannot be precisely reproduced by coarse scale global climate models and therefore downscaling the coastal current system to fine resolution scales is needed.

Objective of the study is providing fine scale 7-years ocean circulation reanalysis and assessment of natural variabilities of physical processes of the coastal ocean by downscaling of coastal current system for Ibaraki prefecture in Japan from 10 km scale parent dataset to related projections of 222 m scale on the Ibaraki coast, particularly taking into account freshwater outflow impact from 3 major rivers (Tone, Naka and Kuji). Our results can be used for adaptation of countermeasures for climate change impact assessment.

Methods

We continued the study from Troselj et al. (2018) with improved downscaling model methodology and extended analyzed period into 7 years (2000-2006). We applied better vertical transformation equation (Vtransform=2, new formulation developed by A. Shchepetkin) and different vertical stretching function (Vstretching=4, where A. Shchepetkin improved double stretching) compared to Troselj et al. (2018). River forcing conditions were applied as observed river temperature and discharge (MLIT, 2017) with constant salinity of 0.5 PSU for Tone, Naka and Kuji rivers.

Discussions

We validated our modelled results with observed sea surface temperature data from Hasaki point (PARI) and satellite images from MGDSST for winter and spring seasons (Figure 1). Results for all seasons will be presented on the conference. The modelled results corresponded well with Hasaki observations in winter and with MGDSST observations in spring season and their mean and variabilities were improved compared to FORA results. Reason for that might be because vertical mixing in spring and summer seasons is lower than in autumn and winter seasons. We expect that Hasaki observations, which are located 2-3 meters below sea level, will have better fit with the modelled results during colder seasons when vertical mixing is higher. Similarly, we expect that MGDSST observations of sea surface layer will

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have better fit with the modelled results during warmer seasons when vertical mixing is lower.

We showed that reproducibility of coastal natural variabilities of physical processes is increased compared to parent dataset FORA when using downscaling, both for sea surface temperature and salinity. Our model reproduced bigger variabilities of both temperature and salinity in vicinity of the coast than in the offshore zone, and it was not well reproduced in FORA.

We showed monthly, seasonal and inter-annual trends in magnitudes and directions of coastal currents. The reproducibility of the trends was improved compared to FORA, because our model provides more precise fine scale representation of coastal currents.

Summary

We conducted dynamic downscaling and reanalysis of coastal current system on the Ibaraki coast particularly considering freshwater outflow impact, with improved methodology and extended targeted period from previous study. We showed that variability of sea surface temperatures in coastal shallow waters is better represented with the downscaling than with the coarser parent model.

Reference

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Keywords: downscaling, coastal current, natural variability, freshwater impact, COAWST, climate change

Keywords: downscaling, coastal current, natural variability, freshwater impact, COAWST, climate change

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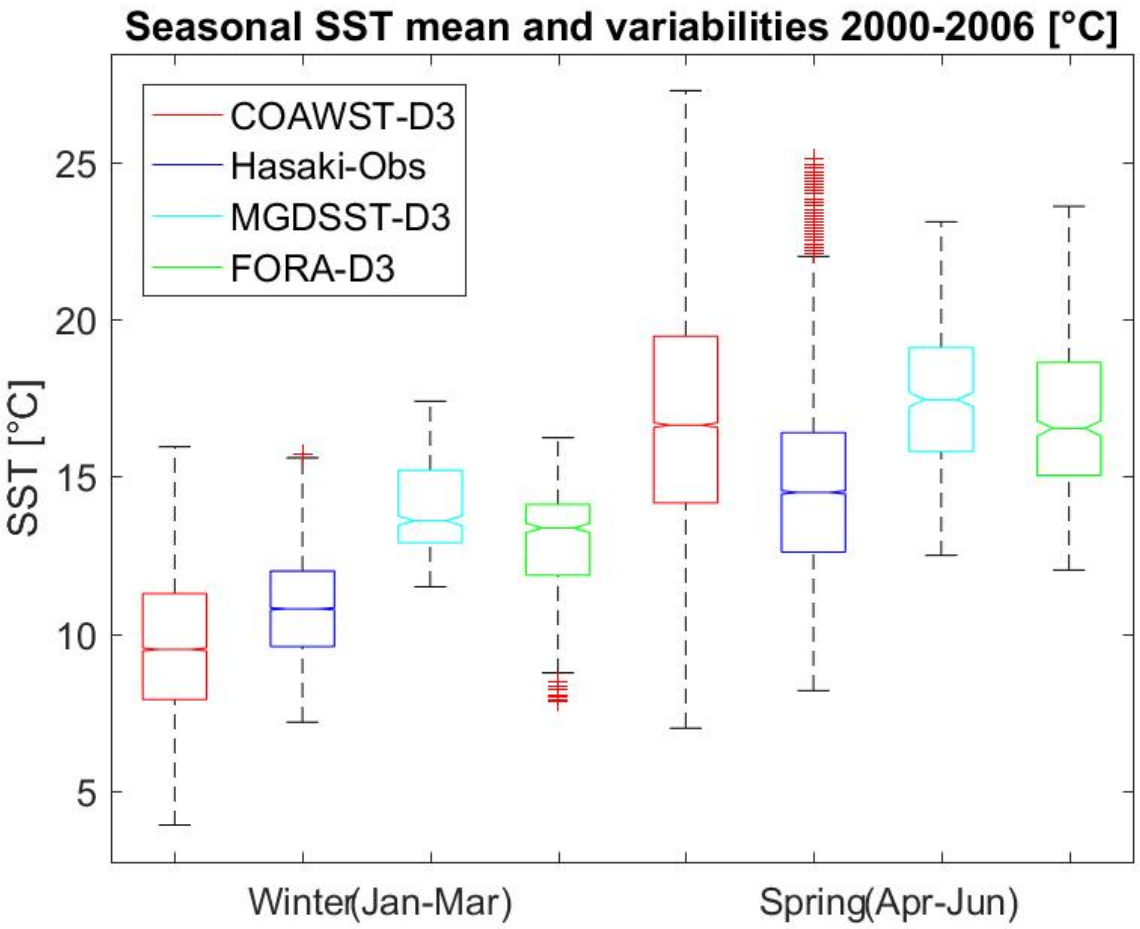

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Estimation of the Japanese sardine stock in relation to the future Kuroshio variability

*Haruka Nishikawa[1], Shiro Nishikawa[1], Tsuyoshi Wakamatsu[2,3], Yoichi Ishikawa[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Nansen Environmental and Remote Sensing Center, 3. Bjerknes Center for Climate Research

Stock of the Japanese sardine (*Sardinops melanostictus*) shows a drastic variation. The principal driver of the stock variation is the Kuroshio velocity, and the second important driver is sea surface cooling. The Japanese sardine spawn in the Kuroshio water of south of Japan during winter and the larvae grow during the transportation by the Kuroshio. Lower the temperature of the Kuroshio water, the nursery ground, more favorable the condition is for feeding and growth of the larvae and consequently the sardine stock becomes higher. Thus the Japanese sardine stock level is strongly affected by the Kuroshio variation. The Kuroshio water temperature in winter tends to be lower during the year of low Kuroshio velocity. This is because, the Kuroshio water from subtropical region can have enough cooling by the time its arrival to near Japan. The Kuroshio velocity has a decadal to multi-decadal scale variation. The past sardine stock variation tended to be higher in the low Kuroshio velocity regime. Since the Japanese sardine is an important commercial fish in Japan, the future sardine stock, especially under the influence of the climate change, is one of the social concerns. The nursery grounds of the Japanese sardines are distributed in the very narrow area along the Kuroshio path and its analysis requires high resolution data. However, the spatial resolutions of the current climate projection products, CMIP5, are generally too coarse to reproduce the narrow Kuroshio path. Recently, we have succeeded at dynamical downscaling of multiple CMIP5 ocean products to 0.1º horizontal resolution products. In this study, we first develop a sardine stock estimation model that reproduce the past stock fluctuation based on the temperature in the nursery grounds. Then we input the future temperature from the downscaled simulation into the sardine stock model to project its future stock. We’ll discuss how the sardine stocks fluctuate in future especially in relation to the Kuroshio variability.

Keywords: Japanese sardine, Kuroshio, Global warming

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[J] Poster | A (Atmospheric and Hydrospheric Sciences)：A-CG Complex & General

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_4

[A-CG43] Adaptation for climate change and social implementation

convener:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience)

Adaptation for climate change is urgent issue since increasing risk of natural disaster, such as typhoon and heavy rain and harmful effect of high temperature on agriculture are expected. "Climate change adaptation law" has passed the National Diet in 2018, in which the vision are given to build a secure, safe and sustainable society that is able to minimizing and avoiding damage. These actions to formulate the adaptation plan are expected to rapidly spread for local governments.
For this purpose, simulation of climate change projection, downscaling technique to obtain the detailed estimation of climate change in local scale, the evaluation of risk to contribute the formulation of adaptation plan are necessary, as well as the issue for social implementation such as co-design working with stakeholders.
We will discuss the current status of the simulation modeling and knowledge gap between the scientists and stakeholders.

[ACG43-P01] Impact of urbanization on the surface air temperature across Bulgaria

*Lidia Lazarova Vitanova[1], Hiroyuki Kusaka[2] (1.Graduate School of Life and Environmental Sciences, the University of Tsukuba, 2.Center for Computational Sciences, the University of Tsukuba)

[ACG43-P02] Clear-air Turbulence over the North Pacific under 2-K Global Warming – Ensemble Projections using a 60-km Atmospheric General Circulation Model

*Shingo Watanabe[1], Mikiko Fujita[1], Sho Kawazoe[1], Shiori Sugimoto[1], Yasuko Okada[1], Ryo Mizuta[2], Masayoshi Ishii[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meteorological Research Institute, Japan Meteorological Agency)

[ACG43-P03] Projections of future beach loss in Japan and uncertainties in projected beach loss

*Keiko Udo[1], Yuriko Takeda[1] (1.International Research Institute of Disaster Science, Tohoku University)

[ACG43-P04] Future projection of forest fire frequency due to climate change in Japan by using predicted relative humidity and wind speed

*Yoshiyuki Yokoo[1], Ren Iwasaki[1] (1.Fukushima University)

[ACG43-P05] Coastal preservation and use of ocean and coastal climate prediction

*Satoshi Takewaka[1] (1.University of Tsukuba)

[ACG43-P06] **Present and Future Potential Distribution of Hill Glory Bower (*Clerodendrum infortunatum* Linn.) using Maximum Entropy Modeling in Doon Valley, Uttarakhand, India.**

*Saurabh Purohit[1,3], Neelam Rawat[2] (1.Indian Institute of Remote Sensing, Dehradun, India, 2.Uttarakhand Space Application Centre, Dehradun, India, 3.Forest Research Institute Deemed University, Dehradun, India)

[ACG43-P07] Development of high-resolution ocean future projection dataset around Japan using CMIP5 atmospheric forcing

*Shiro Nishikawa[1], Tsuyoshi Wakamatsu[2], Yoichi Ishikawa[1], Hiroshi Ishizaki[1] (1.JAMSTEC Japan Agency for Marine-Earth Science and Technology, 2.Nansen Environmental and Remote Sensing Center/Bjerknes Center for Climate Research)

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This study investigated the impact of urbanization on the surface air temperatures across Bulgaria. Our target locations are the major Bulgarian cities –Sofia, Plovdiv and Varna. In this study, we use the Weather Research and Forecasting (WRF) model with 1-km horizontal resolution to simulate month of July between 2011 and 2013. First, the results from the control simulation were verified against observations. The results show that the WRF model reproduced reasonably the diurnal temperature distributions for both of urban and rural areas. The model mean biases ranged from –0.76 to 0.19 ˚C. Second, the impacts of the urbanization on the surface air temperatures are evaluated. The results showed significant nocturnal temperatures increases by 2.6, 2.9 and 2.2 ˚C in Sofia, Plovdiv and Varna compared to those in the rural areas, while in daytime these increases are around 1.0 ˚C.

Keywords: Urbanization, Weather Research and Forecasting model, Bulgarian cities

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Keywords: Clear Air Turbulence, Climate Change

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Projections of future beach loss in Japan and uncertainties in projected beach loss

*Keiko Udo[1], Yuriko Takeda[1]

1. International Research Institute of Disaster Science, Tohoku University

The beach is an important space that has functions of disaster prevention, environment and use, but beach erosions are reported all over the world. In Japan, significant beach erosion has occurred simultaneously with national land development during the rapid economic growth period and the problem has not been solved at present. There is further concern that sea level rise and typhoon enlargement caused by climate change exacerbate the erosion. In this study, we analyze past national beach erosion using sediment mass data of the entire river and coastal basin, project future beach loss due to climate change, and evaluate its uncertainty.

Keywords: Beach loss, Sediment budget, Sea level rise, Sediment yield

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Future projection of forest fire frequency due to climate change in Japan by using predicted relative humidity and wind speed

*Yoshiyuki Yokoo[1], Ren Iwasaki[1]

1. Fukushima University

The present study estimated future frequency of forest fires to investigate the effects of climate change until the end of 21st century in Japan. We firstly developed an empirical model to estimate forest fire frequency based on the statistical relationships between mean forest fire frequency and their background physiographic conditions in the past. Then we estimated the forest fire frequency in future with relative humidity and wind speed estimated until 2100. Here we used the statistically down-scaled relative humidity and wind speed data generated by Institute for Agro-Environmental Sciences, NARO, Japan with the climate models of GFDL-CM3, HadGEM2-ES, MIROC5 and MRI-CGCM3.0 and the scenarios of RCP2.6 and RCP8.5. The results showed that mean-monthly frequency of future forest fires will not significantly until 2100 and seasonal change of the frequency will remain dominated in future.

Keywords: relative humidity, wins speed, topography

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Coastal preservation and use of ocean and coastal climate prediction

*Satoshi Takewaka[1]

1. University of Tsukuba

Followings will be discussed in the presentation:
- Coastal preservation by the local governments
- Sea and coastal information use for coastal preservation
- Future prediction of sea and coastal information in SI-CAT research project

Keywords: coastal preservation, sea and coastal climate, prediciton

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Present and Future Potential Distribution of Hill Glory Bower (*Clerodendrum infortunatum* Linn.) using Maximum Entropy Modeling in Doon Valley, Uttarakhand, India.

*Saurabh Purohit[1,3], Neelam Rawat[2]

1. Indian Institute of Remote Sensing, Dehradun, India, 2. Uttarakhand Space Application Centre, Dehradun, India, 3. Forest Research Institute Deemed University, Dehradun, India

Spatial distribution of flora and fauna can help in its habitat restoration and conservation management. The present study was undertaken for identifying the current and future geographical extent in different climate change scenarios for *Clerodendrum infortunatum* Linn. (Verbenaceae), commonly known as Hill Glory Bower, which is an important medicinal shrub found in the Himalayan Foothills. We have used MaxEnt species distribution model for predicting the present and future distribution for Hill Glory Bower. Total of ninety-one occurrence records were collected using handheld GPS throughout the Doon Valley. Nineteen Bioclimatic layers, two topographic variables and one biophysical layer were initially used. We have also modeled the future distribution of Hill Glory Bower in valley based on two Climate Change projections (RCP 4.5 and RCP 8.5) using an General Circulation Model (MIROC5). The results have shown that the model was fairly accurate with Area Under Curve (AUC) being 0.842. Output indicates that current habitat would shrink in both the cases (RCP 4.5 and RCP 8.5) but in comparison to RCP 4.5 conducive habitat will increase in RCP 8.5. Our findings can be applied in identifying the currently suitable zones as well as future expansion of the habitat of Hill Glory Bower.

Keywords: C. infortunatum, Doon Valley, MIROC5, AUC, RCP 4.5, RCP 8.5

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Development of high-resolution ocean future projection dataset around Japan using CMIP5 atmospheric forcing

*Shiro Nishikawa[1], Tsuyoshi Wakamatsu[2], Yoichi Ishikawa[1], Hiroshi Ishizaki[1]

1. JAMSTEC Japan Agency for Marine-Earth Science and Technology, 2. Nansen Environmental and Remote Sensing Center/Bjerknes Center for Climate Research

One of the subthemes in the SI-CAT project (Social Implementation of Climate Adaptation Technology, funded by MEXT, Japan) is development of the near future ocean projection database which contributes to the adaptation plan for climate change in local governments in Japan. For this purpose, we have developed North Pacific model with 10km horizontal resolution (SICAT10 model) and regional ocean model around Japan with 2km horizontal resolution (SICAT02 model). We have adopted several CMIP5 models and scenarios (historical, RCP8.5, and RCP2.6) to compose the surface atmospheric forcings for ocean future projection simulation. Using the CMIP5 atmospheric forcings and the SICAT10 model, we have performed ocean future projection experiments from 1980 to 2100 with several cases and scenarios, and produced the ensemble dataset (about 800 years). We have also performed downscaling experiments using this dataset and the SICAT02 model to produce higher horizontal resolution dataset of ocean future projection around Japan, where the cases and scenarios are chosen based on the needs in the SI-CAT project. The basic spec of the SICAT10 model is similar to the ocean reanalysis dataset FORA, and we have also prepared some reference datasets including the realistic historical simulation using the atmospheric reanalysis data JRA55 and the downscaling products using JRA55 and FORA. The practicability of cross validation with these realistic products is one important feature of the above ocean future projection products. We have confirmed some basically reasonable reproducibility of historical simulation fields and climate change responses (e.g., SST, SSH, and transports around Japan) and found some differences between the CMIP5 cases through the validations. Details of the datasets and validations will be shown in the presentation.

Keywords: Ocean future projection simulation, Downscaling, CMIP5, SI-CAT

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Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 301A 3F

[A-CG43] Adaptation for climate change and social implementation

convener:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), Shingo Watanabe(Japan Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Yoichi Ishikawa(JAPAN Agency for Marine-Earth Science and Technology), KOJI DAIRAKU(National Research Institute for Earth Science and Disaster Resilience)

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3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[ACG43-07] Recent progress of Japan's regional downscaling project (SI-CAT) and CORDEX Asia Empirical-Statistical Downscaling (ESD)

*KOJI DAIRAKU[1] (1.National Research Institute for Earth Science and Disaster Resilience)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[ACG43-08] Assessment of Flood Risk in Hokkaido, northern Japan, Associated with Climate Change

*Hoshino Tsuyoshi[1], Tomohito J Yamada[1], Dzung Nguyen-Le[1], Masaru Inatsu[1], Tomonori Satou[1], Hiroaki Kawase[2] (1.Hokkaido University, 2.Meteorological Research Institute)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[ACG43-09] Intensification of sub-daily and daily rainfall extremes from densely distributed records for Japan

*Megumi Watanabe[1], Sayaka Yoshikawa[1], Shinjiro Kanae[1] (1.Tokyo Institute of Technology)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[ACG43-10] A Content-Based Database System for Large Ensemble Future Climate Simulations

*Yujin Nakagawa[1], Shintaro Kawahara[1], Fumiaki Araki[1], Daisuke Matsuoka[1], Yoichi Ishikawa[1], Mikiko Fujita[1], Shiori Sugimoto[1], Yasuko Okada[1], Sho Kawazoe[1], Shingo Watanabe[1], Masayoshi Ishii[2], Ryo Mizuta[2], Akihiko Murata[2], Hiroaki Kawase[2] (1.Japan Agency for Marine-Earth Science and Technology, 2.Meteorological Research Institute)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[ACG43-11] Climate change impact assessment in Shikoku with the ensemble climate prediction database d4PDF

*kouhei yoshimura[1], Nasu Seigo[1], Patricia Sanchez[2] (1.Kochi University of Technology, 2.University of the Philippines Los Baños)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[ACG43-12] Caution zone quantification risk to sediment disaster adaptation due to climate change

*SEIKI KAWAGOE[1], YOSUKE SAITO[1], HIROMICHI SUZUKI[1] (1.Fukushima university)

Recent progress of Japan’s regional downscaling project (SI-CAT) and CORDEX Asia Empirical-Statistical Downscaling (ESD)

*KOJI DAIRAKU[1]

1. National Research Institute for Earth Science and Disaster Resilience

As a Japan’s national project, SI-CAT develops reliable technologies to find climate change adaptation measures in collaboration with researchers of geoscience, social science and humanities, and officials of local governments from the beginning of the project to avoid and reduce various threats of climate change.

We conducted dynamical downscaling experiments with horizontal grid spacing of 5km and 2km to reproduce regional climate information. We examine the performance of the regional climate model (NHRCM) to represent severe precipitation events occurred around Gifu and Nagano region. To examine the performance in ungauged mountainous regions, the runoff analysis was conducted. It indicates the overestimation of precipitation. We conduct the ensemble downscaling experiments using database for Policy Decision making for Future climate change (d4PDF) to detect the climate change impact in this region.

Multi-model large ensemble regional climate scenarios over Japan and CORDEX Asia are developed by using CMIP5 GCMs (RCP2.6 and RCP8.5) and a statistical downscaling (Bias Corrected Spatial Disaggregation (BCSD)) to investigate uncertainty of projected change associated with structural differences of the GCMs for the periods of historical climate (1950-2005) and near future climate (2026-2050). Uncertainty range information of the regional climate scenarios support various regional adaptation measures and informed decision making. Based on the SI-CAT experiences, the CORDEX Asia ESD group enhances and integrates the science and application of downscaling activities in Asia by sharing and exchanging data, knowledge, and techniques.

Keywords: Dynamical downscaling, Statistical downscaling, Multi-model ensemble, CORDEX, Asia

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Assessment of Flood Risk in Hokkaido, northern Japan, Associated with Climate Change

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In August 2016, 4 typhoons sequentially attacked Hokkaido region (Northern part of Japan) within 2 weeks and caused severe flood damage. Because this sequential typhoon attack is the first time in recorded history and remarked maximum rainfall amount on many observatories in Hokkaido region and this heavy rainfall caused various flood disaster (inundation caused by dyke break, damaged to load and farmland), it became one of a trigger that led river administrators (Hokkaido regional development bureau of the Ministry of Land, Infrastructure and Transport (MLIT) and Hokkaido prefectural government) to consider flood risk change associate with climate change. Actually, they organized a committee in order to project future flood risk in Hokkaido. MLIT has also organized a committee since fiscal 2018 in order to consider flood prevention plan associate with climate change. As can be seen these backgrounds, projection of future flood risk became important and urgent issue. This study quantified flood risk under both historical and warmer climate condition by using a large ensemble simulation dataset.

In this study, we analyzed characteristics of annual maximum rainfall over river basins in Hokkaido region under historical and warmer climate conditions in order to evaluate flood risk change. This research used d4PDF (database for Policy Decision making for Future climate change) which consists of large ensemble climate data (historical climate: total 3,000 years, 2K warmer climate: total 3,240 years, 4 K warmer climate: total 5,400 years). This research conducted dynamical downscaling (DS) using a regional climate model for annual maximum rainfall events detected from d4PDF (convert from 20 km to 5 km) in order to take into account topographic effect and shapes of the target river basin more precisely. This research focus on not only rainfall amount but also weather pattern which caused heavy rainfall. We classified weather patterns based on SOM (Self Organizing Map) and evaluated their return period.

The rainfall after DS under historical climate condition and rainfall obtained from observation results have similar frequency in terms of rainfall amount and include many events which exceed maximum recorded rainfall. These results show that DS is effective way to make many possible heavy rainfall patterns. The comparison between historical and future climate showed that rainfall amount significantly increase. Especially, low probability rainfall (e.g. 99 percentile value) become much heavier. Because of the increase of rainfall amount, estimated inundation area become larger and estimated fatalities increase under same occurrence probability. Climate change caused not only increase of rainfall amount but also concentration of heavy rainfall in spatiotemporally. Because heavier and more concentrated rainfall causes increase of peak discharge and change of characteristics of flood damage, the change of rainfall characteristics must be considered for flood disaster prevention plan. Classification of weather pattern shows the factor of heavy rainfall changes in warmer climate.

These results show necessity of flood protection plan considering climate change and large ensemble climate dataset can be greatly helpful for planning. This study became the core of the discussion at the committee related to future flood risk in Hokkaido, Japan which was held in fiscal 2017, future flood control measures are going to be discussed based on these results.

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Keywords: Climate change, Flood risk, d4PDF, adaptation

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Intensification of sub-daily and daily rainfall extremes from densely distributed records for Japan

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1. Tokyo Institute of Technology

Rainfall intensity is projected to increase in most regions under warmer climates, and the increase in heavy rainfall will be larger than that in the mean rainfall. The increase in rainfall intensity caused by global warming was often predicted by studies with climate models. There is an argument that climate models tend to underestimate the observed changes in heavy rainfall intensity. Meanwhile, it has been suggested that, to first order, the intensification of heavy rainfall in a warmer climate could follow the Clausius-Clapeyron (CC) relationship which states that warmer air has a higher water vapor holding capacity. According to the C-C relationship a rainfall intensities are estimated to increase by ~7% per degree warming. However, observed evidence that detects CC-related changes both in daily and sub-daily (e.g., hourly) rainfall extremes between two periods (namely the past and the present) is limited. A comprehensive result derived from observed data confirmed that the intensification rate of daily precipitation is close to the rate of CC in Europe, but their analysis was done for daily precipitation only and limited observation data over a large region was used. Another recently published analysis for Australia shows on average a CC-like response for daily extremes and a super-CC (double to triple CC) response for hourly extremes which is also suggested in temperature-rainfall scaling. Nevertheless, large regional variability in their results derived from sparsely distributed observations from the tropics to mid-latitude calls for an analysis of densely-distributed observations in a single climatic zone. In this study, we try to analyze whether the CC relationship, or super-CC, can be applied to the intensification of both daily and sub-daily rainfall extremes over Japan. We also try to show the sensitivity of the estimated intensification of rainfall extremes caused by setting of the past and present period, referenced stations. We used rainfall data at more than 700 stations with less than 1% missing data for the entire area of Japan. We divided whole observation period into the past and present period. We then defined extreme precipitation criteria in the previous period at each individual observation point and counted the number of the event of extreme precipitation. Finally, we calculated the intensification rate of rainfall extremes from the past to present period. In the results, we show that the intensification rate of sub-daily extremes is higher than that of daily extremes. However, the magnitude of intensification rate greatly differs depending on referenced period, the number of stations and rate of increase in temperature.

Keywords: Clausius-Clapeyron, observations, warmer climate

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A Content-Based Database System for Large Ensemble Future Climate Simulations

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1. Japan Agency for Marine-Earth Science and Technology, 2. Meteorological Research Institute

Analyses of large ensemble data of future climate are quite useful in order to produce probabilistic future projection of climate change in various interdisciplinary fields related to, e.g., hydrology, civil engineering, adaptation planning for global warming. Ensemble data of "+2K future climate simulations" are currently generated by "Social Implementation Program on Climate Change Adaptation Technology" (SI-CAT) as a part of a database for Policy Decision making for Future climate change (d4PDF; Mizuta et al. 2016) produced by Program for Risk Information on Climate Change. Those data consist of global warming simulations and regional downscaling simulations around Japan. Considering that those data volumes are too large, i.e. a few petabytes, to download to a local computer of users,
a user-friendly system is required to search and download data which satisfy requests of the users.
In order to provide functions to extract necessary data from +2K future climate simulations to the users, we developed “System for Efficient content-based retrieval to Analyze Large volume climate data (SEAL)”. Existing web-based search systems for climate simulations are designed to find data files using metadata associated with a data file itself. On the other hand, the SEAL allows the users to extract necessary data using metadata associated with contents of a data file such as physical values. The SEAL mainly consists of a relational database, a data download function and web-based user interface. Among the three main features, a key role is provided by the relational database using PostgreSQL which is designed to be registered temporally and spatially compressed data. The data download function allows the users to download temporally and spatially extracted data based on search results obtained by the relational database. In addition, the web-based user interface allows the users to easily use the relational database without knowledge about PostgreSQL. We also prepare a guidebook for usage of the SEAL. The SEAL is currently in test operation on our local server for SI-CAT members.
The SEAL and the guidebook will be released on Data Integration and Analysis System Program (DIAS) after end of fiscal year 2018. Techniques of the SEAL might be quite useful for simulation, experimental and observational data in other research fields. We report functions and some case studies of the SEAL.

Keywords: Climate Change, Relational Database

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Climate change impact assessment in Shikoku with the ensemble climate prediction database d4PDF

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In considering water disaster prevention as a climate change adaptation policy, it is necessary to utilize the climate change projection model. However, the projection model output has some problems mainly in spatiotemporal resolution, bias and uncertainty. When preparing countermeasures according to disaster risks in each region, these problems and characteristics of these GCMs must be taken into consideration. In the presentation of last year, we evaluated the impact in the Yoshino River basin climate change prediction model output CMIP 5 with statistical downscaling, but some problems were clarified.It is important to apply dynamical downscaling including a large number of outputs for appropriate impact assessment.

We used the ensemble climate prediction database d4PDF to evaluate the impact of climate change in the Yoshino River Basin in this study. We made a comparison with the grid near Sameura Dam in the Shikoku mountain area, Tokushima and Kochi. In the Shikoku mountains, the observation rainfall amount are close to members with a lot of rain ,and in Tokushima it was close to members with little rainfall. In Kochi, the model output can not reproduce heavy rainfall caused by typhoon or special factors that occurred in the past. As a result, it is clear that it can be utilized without bias correction for the risk assessment if the scale and rainfall characteristics of the Yoshino river basin area, but it can not be used as it is in smaller rivers and rivers with localized rainfall.

In Sameura Dam, a renewal project to expand the drainage channel is planned. This project makes it possible to release dam water more quickly and increase flood control capacity. At the same time, dam operator are planning to revise the operation rules and increase the ability to respond to large floods.
In order to develop climate change adaptation measures utilizing Sameura Dam, which is a key to flood control and water use in the basin, we should optimize the dam operational rule according to not only flood flow rate but also the trend of the dam reservoir volume of the long term. In order to estimate the dam water level at the time of large scale flooding, we compared the relationship between the discharge rate into the dam and the amount of monthly rain in April to June. GCM greatly differed from non-global warming experiments in each GCM, GCM increased the occurrence of floods from low rain, and GCM tended to have more precipitation in the year when flooding occurred. Compared with the non-global warming experiment, the trend greatly differs in each GCMs. A GCM has the trend increasing the occurrence of floods in drought condition, and other GCM tended to have more precipitation in the year when flooding occurred. For this reason, it is difficult to fixedly change the operational rules of the dam, and it is considered that an "adaptive" approach is required according to changes in rainfall characteristics due to climate change.
In addition, as a result of interviews with local government in the downstream section, it became clear that they are concerned about the risk of complex disasters of flooding in and out of water. Due to heavy rain caused by typhoons and the like, inundation flooding occurred, there is a possibility that evacuation routes in urban areas will be disrupted. In addition, the rainfall in the upstream generated flood and it reaches the downstream section after several hours, and is exposed to the risk of flooding the outside. For this reason, the flood flow rate in the downstream section and the time difference from the rainfall occurrence to the flood arrival were analyzed. The time from heavy rain to flood reached fluctuated

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stronger than the current reproduction. As a result, it became clear that diversification of complex disaster scenario is necessary.

Keywords: climate change adaptation, d4DPF, river management

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Caution zone quantification risk to sediment disaster adaptation due to climate change

*SEIKI KAWAGOE[1], YOSUKE SAITO[1], HIROMICHI SUZUKI[1]

1. Fukushima university

Heavy rainfall disaster is predicted by extermination metrological condition due to climate change. We must estimate future risk based on trend in the future. It's necessary to manage sustainable counter measures to shift smoothly from present to future. In this study, risk evaluation is obtained to apply climate model outputs. We developed high resolution landslide risk model (Saito et al, 2017), and showed risk distribution information. These risk distribution indicate to pay attend some scenario conditions (Rain condition: directly rain outputs, and probable maximum precipitation condition, Time scale: near future and future, RCP scenario: 2.6 and 8.5). Especially, this study result indicate potential risk by probable maximum precipitation. This result predict to target of upper limit to disaster mitigation. It is useful of mitigate planning at regional area. Therefore, this risk outputs target to sediment disaster caution zone. Sediment disaster caution zones set high risk area, and it is a set area to give priority to a disaster prevention measure as an area in present.

As results, it was possible to specify about 10000 points of high dangerous area. Therefore, An adaptation method to these point group was planned.

Keywords: Probable maximum precipitation, disaster, adaptation

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[E] Oral | H (Human Geosciences)：H-GG Geography

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 106 1F

[H-GG01] Human-Natural system interactions and solutions for environmental management

convener:Yuei-An Liou(National Central University), Chairperson:Yuei-An Liou(Center for Space and Remote Sensing Research (CSRSR)), Kim-Anh Nguyen(National Central University)

Natural system, environmental quality, and anthropogenic processes interact with each other closely. Environmental changes and their causes increase the needs to address the consequences taking place in the structural and functional ecosystems. Much progress of anthropogenic activities has been made and significantly improves social economics. However, human system has been altering and raising burden on the natural system by alerting land use and land cover, bringing up water, soil and air pollution, changing regional and global climate, and increasing frequency of natural disasters, e.g., floods, landslides. Planners are increasingly pressured by the challenges in balance between demands and development, while lessening the detrimental impact of social processes on environment. Remote sensing and GIS have been proven with their advantages in providing data and tools to model and visualize spatiotemporally environmental changes and influential factors so that practical policy for environmental protection and management can be proposed.
This session seeks for papers on advancements in the development of techniques and models with remote sensing and GIS to contribute environmental applications, to exhibit and visualize influences of human activities on environmental changes, and to improve understanding of the relationship between anthropogenic activities and natural system and climate patterns. Solutions for environmental management in short- and long-term visions are very welcome.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[HGG01-01] Monitoring of Subsidence Area of Jakarta City using PS-InSAR

*Josaphat Tetuko Sri Sumantyo[1] (1.Center for Environmental Remote Sensing, Chiba University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[HGG01-02] **Understanding and classifying spatial patterns of global eco-environmental vulnerability**

*Kim-Anh Nguyen[1], Yuei-An Liou[1] (1.National Central University, Taiwan)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[HGG01-03] Human-water interface in hydrological modeling: Current status and future directions

*Yoshihide Wada[1] (1.International Institute for Applied Systems Analysis)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[HGG01-04] **Urban greenspace spatial patterns and eco-function by using Sentinel 2 imagery**

*Yuei-An Liou[1], Kim-Anh Nguyen[1] (1.National Central University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[HGG01-05] Assessing performance of L-band SAR backscatter for above ground forest biomass estimation over complex topography

*Waqar Mirza Muhammad[1], Ji Yaqi[1], Josaphat Tetuko Sri Sumantyo[1], Hasil Khan[1] (1.Chiba University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[HGG01-06] **Feasibility Analysis of Engineering Monitoring Using the VLP-16 LiDAR Puck: A Case Study in Henglingshan Tunnel**

*Zhen-Yu Wu[1], Shen Yu Hsiao[1], Yan-Jyun Lin[1], Ren-Jhih Yang[1] (1.National Chung Hsing University)

Monitoring of Subsidence Area of Jakarta City using PS-InSAR

*Josaphat Tetuko Sri Sumantyo[1]

1. Center for Environmental Remote Sensing, Chiba University

Jakarta city proposed the Jakarta Giant Sea Wall as waterfront city for new urban settlement zone, and deep seaport for new economic zone along coastal area at northern Jakarta. This research investigated land deformation at eleven watersheds of West Java Mega Urban Region (WJMUR) using Persistent Scatterer Interferometry (PSI) technique of ALOS PALSAR data. The result shows that land deformation at study area, especially Bandung city area gives significant impact to sedimentation velocity along eastern Jakarta strait, especially deep seaport for 43 years later. This research recommends to evaluate land conservation at upland watersheds, and well management of artificial canals to reduce the impact of sedimentation at Jakarta strait, especially new depth seaport.

Keywords: DInSAR, Peatland, Assesment, ALOS 2 PALSAR 2

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Understanding and classifying spatial patterns of global eco-environmental vulnerability

*Kim-Anh Nguyen[1], Yuei-An Liou[1]

1. National Central University, Taiwan

Anthropogenic processes cause profound changes to natural systems and result in a consistent decline in the quality of eco-environment. In this paper, a framework that aims to qualify eco-environmental vulnerability levels over the global scale has been presented for decision making. The global map of eco-environmental vulnerability was generated by using easily accessible datasets. The vulnerability is classified into six levels consisting of *potential*, *light*, *slight*, *medium*, *heavy*, and *very heavy.* Eco-environmental vulnerability tends to be high and very high in Asia and Africa with leading countries China, India and Ethiopia. Spatial patterns of eco-environmental vulnerability are driven by human and natural disturbances including socioeconomic, natural hazards, hydrometeorology, topography and land resources, among which population growth and natural hazards are the key drivers. $PM_{2.5}$ that can be considered as a hazardous substance in the human environment and an anthropogenic disturbance associated with nature and human-made influence was selected to validate the global eco-environmental vulnerability map. It is demonstrated that global eco-environmental vulnerability map has high correlation with $PM_{2.5}$ distribution patterns with correlation coefficient approximately 0.82 based on 100 validating points. Outcomes of this study include the mapping of global eco-environmental vulnerability and eco-protection zones that provide key hotspots of eco-environmental vulnerability at global scale for informing the decision makers and the people to take actions to lessen the disturbances and achieve environmental sustainability

Keywords: global eco-environmental vulnerability, human and nature, environmental sustainability

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Human-water interface in hydrological modeling: Current status and future directions

*Yoshihide Wada[1]

1. International Institute for Applied Systems Analysis

The Earth’ s surface has undergone drastic changes due to the human-driven alteration of land use and vegetation patterns and the management of surface water and groundwater systems. Over the last century, the global population has quadrupled and currently exceeds 7 billion, half of which live in urban areas. Human needs for water are ever-increasing, dominated currently by agricultural irrigation for food production worldwide, while rapid urbanization and economic development are likely to be the main drivers for increasing water demands in coming decades. The phenomenal growth of the human footprint has significantly modified hydrological processes in various ways (e.g., irrigation, artificial dams, and water diversion) and at various scales (from a watershed to the globe). During the early 1990s, awareness of the potential for increased water scarcity led to the first detailed global water resource assessments. Shortly thereafter, in order to analyse the human perturbation on terrestrial water resources, the first generation of large-scale hydrological models (LHMs) was produced. However, at this early stage few models considered the interaction between terrestrial water fluxes and human activities, including water use and reservoir regulation, and even fewer models distinguished water use from surface water and groundwater resources. Since the early 2000s, a growing number of LHMs have incorporated human impacts on the hydrological cycle. Notwithstanding such growing sophistication, most current-generation of LHMs still fall short of simulating the direct human influence on the terrestrial freshwater systems, leaving the task of representing human land-water management activities within these models, and consequently in Global Circulation Models and Earth System Models, as one of the grand challenges for the hydrologic research community. In this talk I would like to provide a synthesis of progress in the development and application of human impact modeling in LHMs. Importantly, I would like to highlight possible ways forward for LHMs linking to emerging socio-hydrology that currently focus on understanding the detailed local and regional processes that integrate humans and water in a coupled hydrological-social system. This talk highlights a number of key challenges and discusses possible improvements in order to better represent the human-water interface in hydrological models.

Keywords: Global Hydrological Cycle, Human Impacts, Water Resources Management

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Urban greenspace spatial patterns and eco-function by using Sentinel 2 imagery

*Yuei-An Liou[1], Kim-Anh Nguyen[1]

1. National Central University

Urbanization is the process of land transformation and area growth to fulfill the needs of accommodating the increased population, infrastructure and facility in the urban area. Hanoi is the capital city of Vietnam. Its government currently has a great ambition to develop it to become an internationalized city. Under Hanoi Master Plan to 2030 and vision to 2050 by Decision 1259/QD-TTg, Hanoi has been reconstructing and reshaping greatly. Its population in 2020 is expected to reach 15 million inhabitants with green public transport system Metro and a huge increased demand on land transformation from natural spaces to dense concreted infrastructure. This current process poses multi-challenges for the current Hanoi City in terms of greening, urban microclimate and urban environment as well as social and physical impacts on its residents. In the recent few years, Hanoi has dynamically changed in particular by reducing the areas of urban greenspaces that play a vital role in maintaining good ecological and environmental characteristics of the city. Sentinel 2 data are used to investigate the change of urban greenspaces in inner Hanoi City during the timeframe from Oct. 2016 - Oct. 2018. Accuracy assessment is conducted by using Google Earth map and field survey data. Results show that urban greenspaces in inner Hanoi City were significantly declined in recent two years from 24 km^2 to 11.1 km^2, or equivalent to percentages of tree-coverage reduced from 15% to 7%, respectively, and with overall accuracies of 97% and 95% and Kappa coefficients of 0.94 and 0.92, respectively. Spatial patterns of eco-function services of urban greenspace are then investigated. Hotspots of risk heat areas are also highlighted in the map. The reduced accessibility and availability of urban greenspaces in inner Hanoi City reveal that the Hanoi citizens are urgently in needs of more greenspaces. It is advised that the Hanoi City Government and decision makers should take serious measures to enhance the greenness and the effectiveness of urban greenspaces for the benefits of citizen’s health. Also, it is indicated that Sentinel 2 data are well suitable for not only visualizing the urban greenspaces, but also offering the guidance for landscape planning and management at a city scale.

Keywords: urban greenspaces, Hanoi Master Plan, Sentinel 2, urban environment

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Assessing performance of L-band SAR backscatter for above ground forest biomass estimation over complex topography

*Waqar Mirza Muhammad[1], Ji Yaqi[1], Josaphat Tetuko Sri Sumantyo[1], Hasil Khan[1]

1. Chiba University

Forest above ground biomass (AGB) estimation is always challenging using SAR backscatter over challenging topography because topographic introduce topographic and radiometric distortion in SAR images. These distortions can be corrected using topographic and radiometric correction methods but these methods are effective over moderate topography. Most of the forest in Pakistan exist over challenging topography. This research is an initial effort to estimate forest AGB of Gilgit-Baltistan, Pakistan. As Gilgit-Baltistan exist in the north of Pakistan, it lies at approximately 5000 m above the sea level. The prime goal of this research is to estimate above ground forest biomass using L-band SAR backscatter. For this, full polarimetric data of ALOS-2 was acquired. Terrain geometric and radiometric correction was performed and backscatter (σ o) was estimated. Resultant σ o was correlated with ground based forest AGB and regression analysis was performed. It was identified that σ HH – σ HV is most sensitive for biomass estimation.

Keywords: SAR, Biomass, Topography, Forest

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Feasibility Analysis of Engineering Monitoring Using the VLP-16 LiDAR Puck: A Case Study in Henglingshan Tunnel

*Zhen-Yu Wu[1], Shen Yu Hsiao[1], Yan-Jyun Lin[1], Ren-Jhih Yang[1]

1. National Chung Hsing University

This study is aimed at monitoring structural stability of time series using a low-cost remote sensing instrument, the VLP-16 LiDAR Puck. Natural disasters, such as typhoons and earthquakes, usually cause hidden damaged on engineering structures. In the past, structural stability monitoring can be done by a traditional 3D laser scanner. However, the price is high. In the study, a small-scale and low-cost scanner, the VLP-16 LiDAR Puck, is used for tunnel deformation monitoring. The study location is in the Henglingshan Tunnel, Taichung, Taiwan. This tunnel is almost 400m long and its appearance is shown in the attached figure. The results from the VLP-16 LiDAR Puck is well compared with those from the Reigl VZ-1000 LiDAR scanner. The comparisons between two scanners include their spatial resolution, accuracy, practicality, convenience, and cost–performance ratio. If the VLP-16 LiDAR Puck is proven to be feasible for tunnel deformation monitoring, we will further investigate its practicality on the other engineering structure monitoring, such as retaining walls, buildings, bridges, and sand-blocking dams.

Keywords: Remote sensing, LiDAR, Tunnel deformation monitoring

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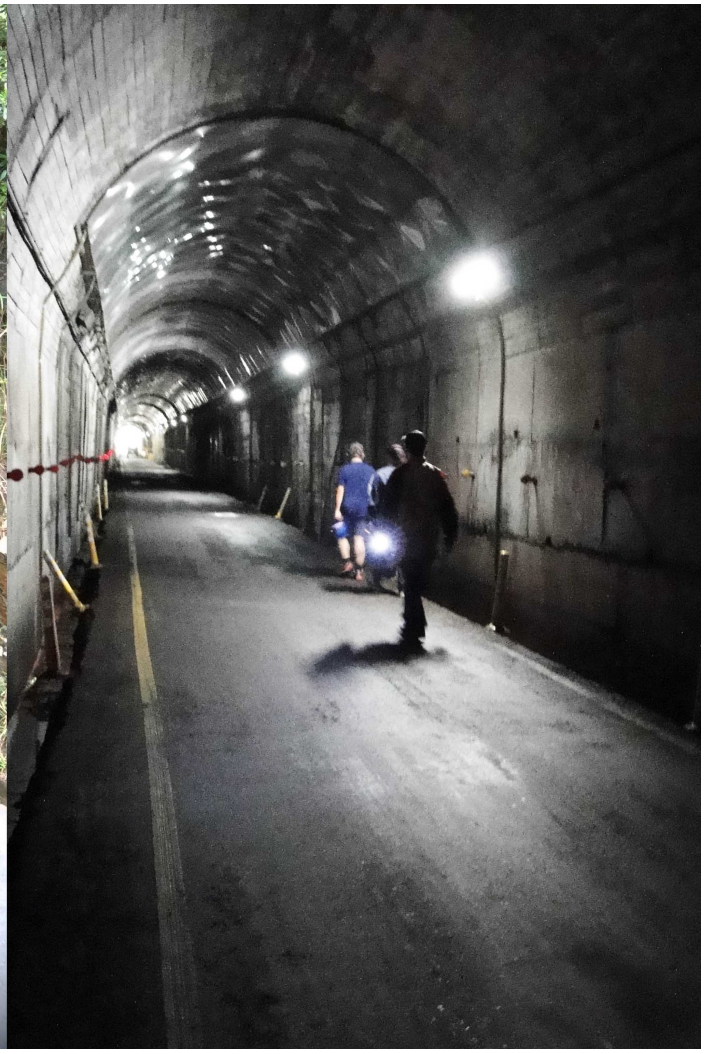

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[E] Poster | H (Human Geosciences)：H-GG Geography

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_8

[H-GG01] Human-Natural system interactions and solutions for environmental management

convener:Yuei-An Liou(National Central University)

Natural system, environmental quality, and anthropogenic processes interact with each other closely. Environmental changes and their causes increase the needs to address the consequences taking place in the structural and functional ecosystems. Much progress of anthropogenic activities has been made and significantly improves social economics. However, human system has been altering and raising burden on the natural system by alerting land use and land cover, bringing up water, soil and air pollution, changing regional and global climate, and increasing frequency of natural disasters, e.g., floods, landslides. Planners are increasingly pressured by the challenges in balance between demands and development, while lessening the detrimental impact of social processes on environment. Remote sensing and GIS have been proven with their advantages in providing data and tools to model and visualize spatiotemporally environmental changes and influential factors so that practical policy for environmental protection and management can be proposed.
This session seeks for papers on advancements in the development of techniques and models with remote sensing and GIS to contribute environmental applications, to exhibit and visualize influences of human activities on environmental changes, and to improve understanding of the relationship between anthropogenic activities and natural system and climate patterns. Solutions for environmental management in short- and long-term visions are very welcome.

[HGG01-P01] Feasibility assessment of constructing high-resolution 3D panoramic images using the VLP-16 LiDAR Puck

*Yan-Jyun Lin[1], Shen Yu Hsiao[1], REN-JHIH YANG[1], Zhen-Yu Wu[1] (1.National Chung Hsing University)

[HGG01-P02] The environmental impact of mountaineering in the Mt. Manaslu region

*Hijiri SHIMOJIMA[1] (1.Tokyo University of Agriculture)

[HGG01-P03] Understanding human system vulnerability to typhoon for Improved Adaptive Capacity

*Kim-Anh Nguyen[1], Yuei-An Liou[1] (1.Center for Space and Remote Sensing Research, National Central University)

[HGG01-P04] Environmental Impact Evaluation of Solar Park Project in Western Desert, Minia, Egypt.

*Ramadan Gamal Abdelrehim[1], Josaphat Tetuko Sri Sumantyo[1] (1.Center for Environmental Remote Sensing, Chiba University)

[HGG01-P05] Peatland Assessment Based on DInSAR approach by using ALOS-2 PALSAR-2 Data in Kalimantan, Indonesia

*Joko Widodo[1], Josaphat Tetuko Sri Sumantyo[1], Daniele Perissin[2], Katsunoshin Nishi[1], Pakhrur Rozi[1] (1.JMRSL - Josaphat Microwave Remote Sensing Laboratory Center for Environmental Remote Sensing Graduate School of Advanced Integration Science Chiba University, 2.Sarproz, Razer Limited, Hongkong)

[HGG01-P06] Development of Nanosatellite for Ionospheric Measurement for Earthquake Prediction

*Peberlin Parulian Sitompul[1], Josaphat Tetuko Sri Sumantyo[2] (1.Chiba University, and Indonesia National Institute of Aeronautic and Space, 2.Center for Environmental Remote Sensing, Chiba University)

Feasibility assessment of constructing high-resolution 3D panoramic images using the VLP-16 LiDAR Puck

*Yan-Jyun Lin[1], Shen Yu Hsiao[1], REN-JHIH YANG[1], Zhen-Yu Wu[1]

1. National Chung Hsing University

We use the low-cost LiDAR sensor “the VLP-16 LiDAR Puck” to capture the surrounding scene for building high-resolution 360° panoramic images. The VLP-16 LiDAR Puck is mounted on a portable automatic lifting platform(see the attached figure) to increase spatial resolution while doing the experiments. The study locations include buildings, landslide areas, and soil&water conservation structures. The results from the VLP-16 LiDAR Puck will be well compared with those from the high-cost LiDAR sensors “the Trimble TX8” and ”The RIEGL VZ-1000”. The comparisons between three LiDAR sensors include their spatial resolution, accuracy, practicality, convenience, and cost–performance ratio. Overall, the purpose of this research is to analyze the feasibility of constructing high-resolution 3D panoramic images with the VLP-16 LiDAR Puck for applications of soil&water conservation. We also hope this new technique of remote sensing can contribute to environmental monitoring and anthropogenic activities.

Keywords: the VLP-16 LiDAR Puck, 3D panoramic images, remote sensing

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The environmental impact of mountaineering in the Mt. Manaslu region

*Hijiri SHIMOJIMA[1]

1. Tokyo University of Agriculture

Manaslu is one of the 8,000-meter peaks ranking as the 8th highest peak in the world, located 130 km northwest of Kathmandu, the capital of Nepal. Since Manaslu's normal route (general climbing route) is relatively less difficult, the number of Manaslu's climbers have increased rapidly over the last 10 years. Sixty years have passed since Manaslu was first conquered by a Japanese expedition. The popularity of its scaling and the rapidly growing tourism in the Nepal Himalayas after 1970 are noticeably affecting natural, social, and cultural environments in the area. This in turn, is creating serious environmental issues at the Manaslu Base Camp (4,800 m above mean sea level), the entry point for climbing Mt. Manaslu.
In this research, we aim to develop a system that can combine high resolution imagery and Digital Surface Model (DSM) in the base camp and simple monitoring into one method in order to estimate the environmental burden associated with the climbing activities in the Manaslu Base Camp. We performed aerial photography of the base camp using Unmanned Aerial Vehicle (UAV) and created DSM from Structure from Motion (SfM) of the obtained images. At the same time, positioning data of the feature was acquired through a Differential Global Positioning System (DGPS) survey, and a 3D topographic map was created.
The geographical area covered in this study is the Manaslu Base Camp in the Manaslu Conservation Area’ s, Gorkha District which is located in Northwest Nepal. In order to elucidate the actual usage of the Manaslu Base Camp, a field survey was carried out in August, 2016 at and around the Manaslu Base Camp using UAV. We conducted the following investigations at the Manaslu Base Camp: survey of the Base Camp, questionnaires to all the mountaineering parties at the Base Camp. We monitored the actual usage of the Manaslu Base Camp in order to clarify the number of tents and their locations by photointerpretation using high resolution satellite images. In the survey of the Base Camp using UAV, we acquired a high resolution image using Phantom 4 of DJI. Using the obtained high resolution image, 3D terrain data and an ortho mosaic image was generated from the SfM, and a map of the Manaslu base camp was created. In the DGPS base camp survey, we recorded location information of features such as tents, toilets and routes in the Manaslu base camp.
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Base Camp. The water was found to be badly contaminated because of the urine and excrement of donkeys that were found scattered over the Base Camp.

Keywords: Himalaya, GIS, UAV

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Understanding human system vulnerability to typhoon for Improved Adaptive Capacity

*Kim-Anh Nguyen[1], Yuei-An Liou[1]

1. Center for Space and Remote Sensing Research, National Central University

Typhoon is one of the most natural disastrous phenomena that have devastating impacts on human system around the world. In the context of climate change, Asian countries particularly in tropical climate zone with high humidity and unevenly-distributed abundant precipitation tend to have frequent occurrence of typhoons and flooding. Here, we present a conceptual framework that incorporates 21 indicators across three dimensions, including vulnerability, exposure/sensitivity, and adaptive capacity to classify vulnerability and adaptive capacity (VAC) using geospatial techniques at regional scales over Vietnam. Results indicate that large spatial differences in VAC are obtained and identify top-priority regions that need enhanced adaptation to typhoons. The Southern Coastal area, South East and Red River Delta exhibit high and very high vulnerability because their physical features tend to be affected by the intensity of typhoons that frequently cross these parts. The lower Mekong Delta and Northern Coastal areas are vulnerable to typhoon-driven flood threats and, in particular, compounded by sea-level rise. Findings of this study are useful in making efficient policy decisions to minimize vulnerability to typhoons in Vietnam. In addition, the framework can be potentially applied to the other regions.

Keywords: human system vulnerability, Typhoon, Adaptive capacity, Geospatial techniques

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Environmental Impact Evaluation of Solar Park Project in Western Desert, Minia, Egypt.

*Ramadan Gamal Abdelrehim[1], Josaphat Tetuko Sri Sumantyo[1]

1. Center for Environmental Remote Sensing, Chiba University

More than 95% of the Egyptian lands are desert, Groundwater in this arid desert area is considered as a very valuable and unique source of water for agricultural and manufacturing development projects; therefore environmental impact evaluation of these projects is very important step to protect groundwater from pollution. Three geophysical techniques used for groundwater exploration and upper geological layers evaluation, these techniques are, Vertical electrical sounding, two dimension electrical imaging, and Time Domain electromagnetic techniques. And depending on this study we described the hydro-geological settings of the area, detect the best locations for drilling groundwater wells, safe environmental injection points, and finally safe environmental landfill.

Keywords: Geophysics, Groundwater, Environmental evaluation, Arid Desert lands

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Peatland Assessment Based on DInSAR approach by using ALOS-2 PALSAR-2 Data in Kalimantan, Indonesia

*Joko Widodo[1], Josaphat Tetuko Sri Sumantyo[1], Daniele Perissin[2], Katsunoshin Nishi[1], Pakhrur Rozi[1]

1. JMRSL - Josaphat Microwave Remote Sensing Laboratory Center for Environmental Remote Sensing Graduate School of Advanced Integration Science Chiba University, 2. Sarproz, Razer Limited, Hongkong

Indonesia has the lagerst tropical peatland ecosystem in the world around 22 million hectares separate in Sumatera Island, Kalimantan Island, and Papua island. Peatlands can be a source of food, clean water, and provide other benefits for the surrounding community. Peatland is also useful for preventing drought, flooding and mixing salt water for irrigation in agricultural areas. Peatlands are important for biodiversity because they are home to rare species. Peatlands play an important role in climate change mitigation and adaptation. Since subsidence is important phenomenon in peatland, DInSAR provide ability and effective aproach to detect subsidence in peatland area. Subsidence phenomenon in peatland related with groundwater table, carbon emision, and others. In this research, DInSAR is very effective as a basis for an approach to conducting peatland assessment in Kalimantan.

Keywords: DInSAR, Peatland, Assessment, ALOS 2 PALSAR 2

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Development of Nanosatellite for Ionospheric Measurement for Earthquake Prediction

*Peberlin Parulian Sitompul[1], Josaphat Tetuko Sri Sumantyo[2]

1. Chiba University, and Indonesia National Institute of Aeronautic and Space, 2. Center for Environmental Remote Sensing, Chiba University

Indonesia is located at equatorial region and also has long coastline that often suffer the earthquakes. In some cases, ionospheric activity level increases just before to an earthquake event and shows a different behaviour 5–10 days before the event, when the seismic event has a magnitude greater than 4–4.5 degrees. The nanosatellite development is very important to get more ionospheric data and reletively cheaper than bigger satellite.

Keywords: Nanosatellite, Circular polarization, Earthquake prediction, Ionosphere

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[E] Poster | H (Human Geosciences)：H-GG Geography

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_14

[H-GG01] Human-Natural system interactions and solutions for environmental management

convener:Yuei-An Liou(National Central University)

Natural system, environmental quality, and anthropogenic processes interact with each other closely. Environmental changes and their causes increase the needs to address the consequences taking place in the structural and functional ecosystems. Much progress of anthropogenic activities has been made and significantly improves social economics. However, human system has been altering and raising burden on the natural system by alerting land use and land cover, bringing up water, soil and air pollution, changing regional and global climate, and increasing frequency of natural disasters, e.g., floods, landslides. Planners are increasingly pressured by the challenges in balance between demands and development, while lessening the detrimental impact of social processes on environment. Remote sensing and GIS have been proven with their advantages in providing data and tools to model and visualize spatiotemporally environmental changes and influential factors so that practical policy for environmental protection and management can be proposed.
This session seeks for papers on advancements in the development of techniques and models with remote sensing and GIS to contribute environmental applications, to exhibit and visualize influences of human activities on environmental changes, and to improve understanding of the relationship between anthropogenic activities and natural system and climate patterns. Solutions for environmental management in short- and long-term visions are very welcome.

[HGG01-P01] Feasibility assessment of constructing high-resolution 3D panoramic images using the VLP-16 LiDAR Puck

*Yan-Jyun Lin[1], Shen Yu Hsiao[1], REN-JHIH YANG[1], Zhen-Yu Wu[1] (1.National Chung Hsing University)

[HGG01-P02] The environmental impact of mountaineering in the Mt. Manaslu region

*Hijiri SHIMOJIMA[1] (1.Tokyo University of Agriculture)

[HGG01-P03] Understanding human system vulnerability to typhoon for Improved Adaptive Capacity

*Kim-Anh Nguyen[1], Yuei-An Liou[1] (1.Center for Space and Remote Sensing Research, National Central University)

[HGG01-P04] Environmental Impact Evaluation of Solar Park Project in Western Desert, Minia, Egypt.

*Ramadan Gamal Abdelrehim[1], Josaphat Tetuko Sri Sumantyo[1] (1.Center for Environmental Remote Sensing, Chiba University)

[HGG01-P05] Peatland Assessment Based on DInSAR approach by using ALOS-2 PALSAR-2 Data in Kalimantan, Indonesia

*Joko Widodo[1], Josaphat Tetuko Sri Sumantyo[1], Daniele Perissin[2], Katsunoshin Nishi[1], Pakhrur Rozi[1] (1.JMRSL - Josaphat Microwave Remote Sensing Laboratory Center for Environmental Remote Sensing Graduate School of Advanced Integration Science Chiba University, 2.Sarproz, Razer Limited, Hongkong)

[HGG01-P06] Development of Nanosatellite for Ionospheric Measurement for Earthquake Prediction

*Peberlin Parulian Sitompul[1], Josaphat Tetuko Sri Sumantyo[2] (1.Chiba University, and Indonesia National Institute of Aeronautic and Space, 2.Center for Environmental Remote Sensing, Chiba University)

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*Yan-Jyun Lin[1], Shen Yu Hsiao[1], REN-JHIH YANG[1], Zhen-Yu Wu[1]

1. National Chung Hsing University

We use the low-cost LiDAR sensor “the VLP-16 LiDAR Puck” to capture the surrounding scene for building high-resolution 360° panoramic images. The VLP-16 LiDAR Puck is mounted on a portable automatic lifting platform(see the attached figure) to increase spatial resolution while doing the experiments. The study locations include buildings, landslide areas, and soil&water conservation structures. The results from the VLP-16 LiDAR Puck will be well compared with those from the high-cost LiDAR sensors “the Trimble TX8” and ”The RIEGL VZ-1000”. The comparisons between three LiDAR sensors include their spatial resolution, accuracy, practicality, convenience, and cost–performance ratio. Overall, the purpose of this research is to analyze the feasibility of constructing high-resolution 3D panoramic images with the VLP-16 LiDAR Puck for applications of soil&water conservation. We also hope this new technique of remote sensing can contribute to environmental monitoring and anthropogenic activities.

Keywords: the VLP-16 LiDAR Puck, 3D panoramic images, remote sensing

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The environmental impact of mountaineering in the Mt. Manaslu region

*Hijiri SHIMOJIMA[1]

1. Tokyo University of Agriculture

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*Kim-Anh Nguyen[1], Yuei-An Liou[1]

1. Center for Space and Remote Sensing Research, National Central University

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Keywords: human system vulnerability, Typhoon, Adaptive capacity, Geospatial techniques

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*Ramadan Gamal Abdelrehim[1], Josaphat Tetuko Sri Sumantyo[1]

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Development of Nanosatellite for Ionospheric Measurement for Earthquake Prediction

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[J] Oral | H (Human Geosciences)：H-GG Geography

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 102 1F

[H-GG02] Use, change, management of natural resources and environment: Interdisciplinary perspectives

convener:Yoshinori OTSUKI(Institute of Geography, Graduate School of Science, Tohoku University), Gen Ueda(Graduate School of Social Sciences, Hitotsubashi University), Takahisa Furuichi(Graduate School of Science, Hokkaido University), Toru Sasaki(Miyagi University of Education), Chairperson:Yoshinori OTSUKI, Gen UEDA

In this session, the situation and history of use, changes and management of natural resources and environment from various regions under diverse socio-economic and natural conditions are reported. Findings from local-scale fieldwork and feedbacks on their methodology and/or research concepts are particularly encouraged to be shared and discussed. A variety of research topics are covered through both human-ecological and earth-scientific perspectives, including local knowledge of natural resources and environment, environmental and climatic history, environmental geography, environmental degradation through resource use and/or management, effects of climate change, related socio-economic changes and adaptation for livelihood security, political ecology, and issues for overcoming gaps in linking between local and broader-scale (national, regional and global) studies.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HGG02-01] Source identification of pottery based on chemical analysis of volcanic glass contained in ceramic paste
- Example for Usultan pottery in Chalchuapa, El Salvador, Central America -

*Shigeru Kitamura[1], Masakage Murano[2] (1.Faculty of Social Welfare, Hirosaki Gakuin University, 2.The Museum of Kyoto)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HGG02-02] Preliminary magnetic biomonitoring study of the spatial distribution of roadside pollution using *Cryptomeria japonica* tree bark

*Nagisa Sawada[1], Kazuo Kawasaki[1] (1.University of toyama)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HGG02-03] Preliminary environmental magnetic results from heavy metal contamination around the Erdenet Cu-Mo deposit, Mongolia.

*Kazuo Kawasaki[1], Ryuki Tonami[2], Solongo Tsetsgee[3], Baasansuren Gankhurel[3], Keisuke Fukushi[4] (1.Graduate School of Science and Engineering for Research, University of Toyama, 2.Department of Earth Sciences, University of Toyama, 3.Kanazawa University, 4.Institute of nature & Environmental Technology, Kanazawa University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HGG02-04] Sediment and its movement as natural resources and environment

*Takahisa Furuichi[1], Sachi Wakasa[2], Shigeru Mizugaki[3], Masanori Nunokawa[3] (1.Graduate School of Agriculture, Hokkaido University, 2.Graduate School of International Resource Sciences, Akita University, 3.Civil Engineering Research Institute for Cold Region)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HGG02-05] Reutilization of waste bamboo from oyster farming

*KIYOSHI SAIJO[1] (1.Miyagi University of Education)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HGG02-06] Regional Impacts of Globally Important Agricultural Heritage Systems in Osaki City, Miyagi Prefecture

*Toru Sasaki[1] (1.Miyagi University of Education)

Source identification of pottery based on chemical analysis of volcanic glass contained in ceramic paste - Example for Usultan pottery in Chalchuapa, El Salvador, Central America -

*Shigeru Kitamura[1], Masakage Murano[2]

1. Faculty of Social Welfare, Hirosaki Gakuin University, 2. The Museum of Kyoto

In volcanic area, volcanic ash is generally utilized for making pottery as one of materials. Then the chemical analysis of the volcanic glass contained in the paste of the pottery can provide available data to clarify the production and the distribution of the pottery. This approach, which is recently being developed in Japanese archaeology, is supposed to be valuable also in El Salvador, Central America, because chemical composition of volcanic glass from the late quaternary tephras in the area has been previously obtained by using a wave-length-dispersive electron microprobe analyzer (WDS).
The present preliminary work aims at illustrating chemical composition of volcanic glass contained in the paste of Usulutan pottery, which is a kind of mesoamerican pottery style in the period from 400 B. C. to 600 A. D. and has been found out in a broad area of Central America. Chemical analyses for two samples, both of which are Usulutan-type ceramic pieces and are collected in Chalchuapa, El Salvador, were performed using the WDS (JEOL JXA-8800RL) in the Department of Global Environment and Disaster Prevention Sciences, Hirosaki University. As a result, the volcanic glass in the both samples is chemically similar to the Arce tephra, ejected from Coatepeque Caldera in 72 ka, particularly to the middle unit of the tephra. This result indicates that the Usulutan potteries analyzed in the study would be produced in the distribution area of the Arce tephra including Chalchuapa. Moreover, volcanic grains with particular size were possible to be collected selectively to make the potteries, because the middle unit of the Arce tephra is finer than the other units around Chalchuapa.

Keywords: a wave-length-dispersive electron microprobe analyzer , analysis of ceramic paste, Arce tephra

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Preliminary magnetic biomonitoring study of the spatial distribution of roadside pollution using *Cryptomeria japonica* tree bark

*Nagisa Sawada[1], Kazuo Kawasaki[1]

1. University of toyama

Magnetic biomonitoring methods have been shown to be effective for monitoring roadside pollution. Most such studies have focused on tree leaves and only a few systematic magnetic investigations have reported on tree barks. However, tree barks could be an effective candidate for biomonitoring because tree barks can be sampled at any height above the ground. Our aim is test the efficiency of using the magnetic properties of *Crypotomeria japonica*, Japanese cedar tree, bark for monitoring roadside pollution and estimating the tree-dimensional distribution of roadside pollution. One bark sample was collected from the road-facing side of the tree and second from the forest-facing side. The samples were collected at heights of 0.5, 1.0, and 1.5 m from the ground at 18 sites along a local road in Suzu-city, Ishikawa, resulting in 108 samples in total. Stepwise isothermal remanent magnetization(IRM) acquisition and subsequent alternative field demagnetization tests indicate that the main magnetic minerals attached to the bark are pseudosingle-domain(PSD) magnetite and maghemite. The maximum saturation IRM intensities occur near the roadside and the intensities decrease rapidly by ~2 m from the roadside. Also, the higher the height above the ground, the lower is the observed SIRM intensity. Therefore, likely the magnetic minerals in tree barks are derived from passing vehicles. The results show that environmental magnetic measurements on tree barks are an effective method for estimating roadside pollution in three-dimensional space.

Keywords: magnetic biomonitoring, roadside pollution, tree bark, Ishikawa

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*Kazuo Kawasaki[1], Ryuki Tonami[2], Solongo Tsetsgee[3], Baasansuren Gankhurel[3], Keisuke Fukushi[4]

1. Graduate School of Science and Engineering for Research, University of Toyama, 2. Department of Earth Sciences, University of Toyama, 3. Kanazawa University, 4. Institute of nature & Environmental Technology, Kanazawa University

The Erdenet Cu-Mo porphyry deposit in Mongolia is one of the largest mines in the world and it has been operating since 1978. The ore processing waste is pumped into a tailings pond that contains ~400 million tons of tailings and 15 million m^3 of supernatant water. Environmental magnetic results are reported here for surrounding topsoils, stream sediments and sediments from the pond. The rock magnetic analyses indicate that the main magnetic minerals are pseudosingle domain magnetite and/or partially oxidized magnetite with minor pyrrhotite. This magnetic mineralogy is consistent through all samples, indicating that the observed fluctuations of magnetic susceptibility and saturation isothermal remanent magnetization (SIRM) intensity record the abundance of magnetic minerals in the samples. Based on geochemical analyses of the topsoils and stream sediments, positive correlations are found between susceptibility and SIRM intensity with heavy metal concentrations such as Cr and Zn. Further, SIRM intensity showed a more positive correlation with heavy metal concentration than susceptibility, implying that some of magnetite may be substituted by metal ions. These results indicate that environmental magnetic monitoring, especially the SIRM intensity, can be a rapid and cost-effective method for studying the spatial distribution of heavy metals in the Erdenet area.

Keywords: Environmental magnetism, Heavy metal contamination, Erdenet Cu-Mo deposit, Mongolia

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Sediment and its movement as natural resources and environment

*Takahisa Furuichi[1], Sachi Wakasa[2], Shigeru Mizugaki[3], Masanori Nunokawa[3]

1. Graduate School of Agriculture, Hokkaido University, 2. Graduate School of International Resource Sciences, Akita University, 3. Civil Engineering Research Institute for Cold Region

1. Introduction

Sediment is not well recognized as a natural resource, compared with, for instance, forest and water. Sediment is also an important constituent of the environment but is not fairly acknowledged. In this paper, we identify benefits derived from sediment as a natural resource as well as a constituent of the environment. Problems caused by sediment movement are also located in various environmental settings. Then, we review an effective analytical framework of sediment movement and give research perspectives on sediment and its movement as natural resources and environment.

2. Terminology of ‘sediment’

‘Sediment’ refers to basically unconsolidated collection of solid particles in the size from clay to boulder consisting of rock clasts, mineral fragments, volcanic materials, weathering residual materials, biological remains etc. Solid particles may be coated by materials from different origins through adsorption and/or precipitation processes. ‘Debris’ is a synonym of ‘sediment’ but tends to be used when cobbles and boulders are included. ‘Deposit’ is also a synonym of ‘sediment’ but may be used particularly for settled sediment. ‘Sediment’ is a useful term which can be used for collection of solid particles in transport and after deposition, regardless of its particle size distribution.

3. Benefit and problems of sediment as natural resources and the environment

Sediment is a resource material for buildings and civil engineering structures. In some areas, humus-rich sediment is collected and distributed to agricultural fields as natural fertilizer. Sediment develops landforms, such as alluvial plains, river banks and beds, coastal banks and beaches, which provide the essential places for human life, agriculture and ecological habitats. On the other hand, sediment can cause various problems. 1) Sediment disaster is one of the most serious sediment-causing problems around the world. Other issues include 2) the problems in water quality and local water transportation in Lake Inle of Myanmar, 3) the problem in water quality by suspended sediment being delivered from many coastal catchments into the Great Barrier Reef lagoon in northwestern Australia, 4) heavy metal pollution by discharge of mine tailing (polluted sediment) from the Bor Mine into the Danube River in Serbia, 5) river incision and/or coastal erosion due to local deficit of sediment, and 6) deterioration of ecological habitat environments due to changes in landforms along rivers and coasts as well as in particle size distribution. Thus, sediment-causing problems commonly occurs by human interventions or extreme events (rain and earthquake) and extreme events (rain) are partly but importantly related to climate change.

4. Sediment budgets as an analytical framework

Many sediment-causing problems are commonly induced by rapid or sudden change in rates of erosion (or discharge) and deposition (or inflow) of sediment. ‘Sediment budgets’ are a quantitative, schematic

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account of sediment movement in the target area, in which erosion (source) and deposition (sink) as well as outflow from the target area (output) are linked. It is displayed in the form of a simple diagram, which makes a sediment budget considerably useful in planning countermeasures for sediment-causing problems.

5. Research perspectives

Given that sediment is clearly a constituent of the environment, it should be better recognized, even in the academic arena, as an important natural resource, like forest and water. Scientific research will objectively analyze both benefits and problems concerning sediment and its movement. Such research encourages the multidisciplinary approach with earth, ecological and social sciences.

Keywords: Land, Agriculture, Habitat, Mine tailing, Sediment disaster, Sediment budgets

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Reutilization of waste bamboo from oyster farming

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1. Miyagi University of Education

The shelves for oyster farming in the Matsushima Bay, Miyagi Prefecture are made of many Moso bamboos. Those bamboos, as being soaked in sea water, become degraded within about three years and be replaced by new ones. As the result, the used bamboos change into waste. It is estimated that about 40 to 50 thousands waste bamboos per year appear from oyster farming in the Matsushima Bay. This study presents that the author's attempts to reutilize these waste bamboos as resources which may contribute to local agriculture and environmental improvement.

Keywords: oyster farming, waste bamboo, local resource, environmental improvement

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Regional Impacts of Globally Important Agricultural Heritage Systems in Osaki City, Miyagi Prefecture

*Toru Sasaki[1]

1. Miyagi University of Education

In this report, I would like to discuss how Globally Important Agricultural Heritage Systems could affect local agriculture, especially the use and management of natural resources.

Keywords: Globally Important Agricultural Heritage Systems, Paddy Field Agriculture, Osaki City, Sustainability

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[J] Poster | H (Human Geosciences)：H-GG Geography

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_15

[H-GG02] Use, change, management of natural resources and environment: Interdisciplinary perspectives

convener:Yoshinori OTSUKI(Institute of Geography, Graduate School of Science, Tohoku University), Gen Ueda(Graduate School of Social Sciences, Hitotsubashi University), Takahisa Furuichi(Graduate School of Science, Hokkaido University), Toru Sasaki(Miyagi University of Education)

In this session, the situation and history of use, changes and management of natural resources and environment from various regions under diverse socio-economic and natural conditions are reported. Findings from local-scale fieldwork and feedbacks on their methodology and/or research concepts are particularly encouraged to be shared and discussed. A variety of research topics are covered through both human-ecological and earth-scientific perspectives, including local knowledge of natural resources and environment, environmental and climatic history, environmental geography, environmental degradation through resource use and/or management, effects of climate change, related socio-economic changes and adaptation for livelihood security, political ecology, and issues for overcoming gaps in linking between local and broader-scale (national, regional and global) studies.

[HGG02-P01] Preliminary magnetic biomonitoring results of the spatial distribution of atmospheric particulate matter in Muroran, Japan

*Hiroki Shibata[1], Kazuo Kawasaki[1] (1.University of Toyama)

[HGG02-P02] Social Foundations of Entomophagy and Its Transformation: A Case Study of Ina City, Nagano Prefecture

*Naoki Kobayashi[1] (1.National University Corporation Kanazawa University)

[HGG02-P03] Cost sharing and free water policy in semi-arid rural Kenya

*Gen Ueda[1] (1.Graduate School of Social Sciences, Hitotsubashi University)

[HGG02-P04] Importance of the stories as the background of nature understanding: an example in the Visayas, the Philippines

*Takashi Ito[1] (1.Faculty of Education, Ibaraki University)

[HGG02-P05] Hydrogeomorphological and environmental geographical land condition of groundwater use areas along the coast of Lake Victoria, west Kenya

*Yoshinori OTSUKI[1] (1.Institute of Geography, Graduate School of Science, Tohoku University)

Preliminary magnetic biomonitoring results of the spatial distribution of atmospheric particulate matter in Muroran, Japan

*Hiroki Shibata[1], Kazuo Kawasaki[1]

1. University of Toyama

Magnetic biomonitoring techniques have been shown to be rapid, cost-effective and useful methods for investigating spatial distribution of air pollution. However, a few studies have been reported such magnetic monitoring in Japan due to: a) lots of volcanos that supply great amount of magnetically-enhanced fly ashes; and, b) the dense population that cause huge amounts of magnetic noise. Here we report environmental magnetic results for the materials deposited on *Sasa kurilensis*, or dwarf bamboo, around the city center of Muroran, Japan. The dust on the leaves are wiped and analyzed their rock magnetic properties. Detailed rock magnetic and low temperature analyses show clearly that the main magnetic minerals in the dust are single to pseudosingle domain magnetite and/or partially oxidized magnetite, and the magnetic mineralogy on leaves' surface is consistent throughout the study area. Much higher saturation isothermal remanent magnetization intensity is observed at eastside of the heavy and chemical industrial area in the city and the local wind had generally come from west to east direction. These results indicate that magnetic biomonitoring using the leaves of dwarf bamboo can be a rapid, non-destructive and cost-effective method for studying the spatial distribution of atmospheric particulate matter derived from local industrial activities even in Japan.

Keywords: Environmental magnetism, Dwarf bamboo, Atmospheric particulate matter, Japan

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Social Foundations of Entomophagy and Its Transformation: A Case Study of Ina City, Nagano Prefecture

*Naoki Kobayashi[1]

1. National University Corporation Kanazawa University

For its nutritional value and so on, insect is receiving attention as a new food resource around the world now. There is food security issues behind the growing interest in Entomophagy. The culture of Entomophagy still survive in a few areas at the present, however, many people in the whole country had the habit of eating insect in the old days in Japan. The author researched a specific example of Entomophagy held in Ina city, Nagano prefecture and analyzed it with regard to the relationship between Entomophagy and local communities. The findings are described as follows.

The research revealed that many people have the habit of eating insect at the present in study area. Also, they recognize insect is the local food and Entomophagy is local food culture of Ina. However, Entomophagy is less popular nowadays especially in the young generation. Furthermore, the method for obtaining insect has changed. There are changing tendency of working patterns, aging and decrease of population behind the change of Entomophagy in the study area.

Paying attention to the relationship between Entomophagy and local communities, people concerned about Entomophagy is different by each insect. Many people hunted, cooked and ate insects which can hunt easily on their own self. However, a few people hunt insects, which need skills or specialized tools to hunt, and to share with other residents or to sell wholesale to retail store. Furthermore, the difference of supplier and attribute of subjects, management of insect resource is different by each insects. In summary, it can be said that the way of relationship between Entomophagy and local people is different among each insect. Also the shape of Entomophagy has been changing in various contexts or perspectives as time goes on.

The research revealed that some changes occurred in Entomophagy of Ina.

The changes are about,

1) The amount of insect and insect products which from other cities are increasing.

2) In part of distribution, the role of retail store is getting bigger.

3) The number of people eating insect and the demand of each insect is decreasing.

Furthermore, the changes occurred to the people concerned about Entomophagy. These changes are connecting to the decreasing insects and people who hunt insect.

Today, it can be said that the culture of Entomophagy has been succeeded. But thinking the risk of Entomophagy in Ina region, such as the decrease of demand of insects or the unstainable supply of insect resources from other regions, the solutions to these problems are required. When it comes to attempting these problems, individual plans fitting each insect are needed, because the supply network of them and their stakeholder in the region are different to each other.

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Keywords: Entomophagy, Food culture

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Cost sharing and free water policy in semi-arid rural Kenya

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In Kilembwa and Kangii, rural areas of Machakos County, Central Kenya, the Government laid the waterworks in 1975, and the Mwala Water and Sanitation Company is now managing it. This waterworks has repeated a stop and restoration in the face of the high pumping cost from the Athi River, and it has a limit in water supply area. Therefore, local people are still depending on boreholes, reservoirs, sand dams, and water scooped from the bed of seasonal rivers. This situation will not change with the installation of a new water supply system (gravity-fed) planned by the Government.

The waterworks and boreholes with support of NGO, JICA, etc. in the study area have supplied water with the cost sharing principle, especially after the water sector reform by 2002 and the 2016 Water Acts. On the other hand, in 2013 and afterwards, the transfer of water supply authority from the National to County governments progressed, and in Machakos, the Governor and Members of County Assembly (MCAs) established many new boreholes towards the general elections in 2017, beginning to supply people free water. This study reports water uses among the people, the relation between cost sharing water provision and free water policy, and the influence of politicization of water provision on its socio-economic sustainability, especially focusing on the following two points.

(1) Catchment areas of water sources and water use
Many existing studies do not consider that water may be used for a productive purpose. This study therefore selected sample households supposing competition between domestic water use and water supply for dairy cattle. It conducted a household random sampling (20%) in 16 Kilembwa villages with the waterworks network nearby and comparatively many dairy cooperative members, and in 9 Kangii village with no waterworks and few cooperative members. It conducted around 200 interviews with these sampled households and cooperative members in the area.

(2) The influence of County free water policy on cost sharing principle of existing boreholes
An NGO-supported borehole with cost sharing principle started to operate in 2009, but it was suspended due to accounting problem of its water committee. The County Government, with an initiative of a local MCA, took over and rehabilitated it, and is supplying people free water from 2017. Views of the local administrative officers and water committee members on this free water policy are in disagreement: some are in the skeptical opinion which casts doubt on the financial strength after the next elections, and others credited the positive statement that understands and supports the policy as encouraging water supply to the poor and avoiding the accounting problem.

Since the cost sharing borehole supported and established by JICA in 2013 was located in the neighborhood of the above-mentioned rehabilitated county borehole with free water, the number of its users decreased, and in spite of water abundance, it stopped operating in 2017 after the vicious circle of a pump fuel financial deficit, a lowering utilization level, and rising "salt" concentration.

The study found some cases in which an NGO and church institution refused to make free their water provision despite the request by the County Government and a ruling party MCA, and a case where the same request resulted in refusal and interruption of an NGO borehole development. This is because they

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tried to secure socioeconomic sustainability of water supply and avoid politicization of borehole provision by those in power.

Keywords: Domestic water supply, rural areas, Kenya

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Importance of the stories as the background of nature understanding: an example in the Visayas, the Philippines

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What kind of a perspective on nature do the children acquire through nature experiences, exchanges with families and surrounding people, and books or media? In this study, I conducted interviews via Skype for tens of young people (generally in their twenties) living in the Visayas region, the Philippines, and collected examples of how or what kind of a perspective on nature get during their childhood. Here, I introduce the tentative results regarding the understanding and experience of people in the Visayas, Philippine against the moon, rain, and forests.

Moon: Regarding the image of the moon surface, they have no common understanding like a rabbit for Japanese. There was also a case who have no experiences to pay attention to the pattern on the moon surface during childhood. On the lunar eclipse, there is a folktale that the sea serpent called Bakunawa ate the moon, but the popularization of the folktale is not high (about half). On the other hand, only the sentence of Gikaon sa Bakunawa (eaten by Bakunawawa) survives. There are cases where that word is used in the scene that people went home without notice or things went missing. The full moon was treated as a negative. They have experiences threatened as “monsters or ghosts become active at night of full moon, so you should go home early."

Rain: The impression of rain is so different from the Japanese. They had a very positive impression against rain, especially during their childhood. Rain is a blessing and a gift from the sky to cool their body. In the rain, most of the people played becoming muddy, running around with friends, washing the body as a natural shower. After returning home, about 70% of people experienced being urged to drink plenty of water after taking shower and changing clothes. On the other hand, against too heavy rain, some people had the habit of cutting clouds or rain grains with “the scissors” made with fingers also remained.

Forest: About the forest, they have a feeling of awe and respect. This is because of the sense that the forest is the place where something other than human beings. In the forest, they do not make noise and they do not point anything by a finger to pay tribute or to avoid disturb something else. Also when they enter into the forest, especially when they pass through beside a big tree, the chant of tabi tabi po (Excuse me) still remains as a habit

Of course in the Philippines, as in Japan, school education treats moon, rain, and forest as part of natural science. On the other hand, we also should keep in mind that indigenous ideas such as those introduced here have penetrated and people in the Visayas are deeply affected. In particular, we should consider being sufficient consideration when implementing natural research or natural education programs in the Visayas as a field.

Keywords: Philippines, Visayas, Nature, Stories, Folktales, Legends

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Hydrogeomorphological and environmental geographical land condition of groundwater use areas along the coast of Lake Victoria, west Kenya

*Yoshinori OTSUKI[1]

1. Institute of Geography, Graduate School of Science, Tohoku University

The objectives of this presentation are to show and discuss about hydrogeomorphological and environmental geographical condition, supported groundwater resource used by drilled wells, of coastal areas of Lake Victoria, Kenya. Settlements in the areas are situated on the fluvial-colluvial lowlands and gentle slopes between the Rangwa composite caldera and the circular, outer Gwasi Hill, in the former Suba district (Homa Bay County).
The lowlands consist mainly of fluvio-colluvial deposits corresponding to principal aquifer, which has high permeability coefficient (1.0E-5 to 1.0E-6 m/s). In the vicinity of the groundwater observation points, water table depth exists 10 to 15 m below the current river bed (dissected valley bottom), approximately 25 m below the surface.
Environmental geographical conditions which are able to maintain the groundwater environment and use as described above will be shown in the presentation.

Keywords: groundwater use, hydrogeomorphology, environmental geography, Lake Victoria, Kenya

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[J] Oral | H (Human Geosciences)：H-QR Quaternary research

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 102 1F

[H-QR05] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Masayuki Hyodo(Research Center for Inland Seas, Kobe University), Chairperson:Ken Ikehara(AIST), Kaori Aoki

Humans have attained their specific development by indigenous cultures and evolved through environmental adaptation. The session raises issues of human-environmental interactions, views from diverse changes of climate, ocean, land and biota having made striking influence on humans. It welcomes various fields from human-environment change and their chronometric dating among Quaternary disciplines.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HQR05-01] Disturbance of sea floor by large earthquake and formation of earthquake-induced event deposit: Where is a suitable location for deep-sea turbidite paleoseismology

★Invited Papers

*Ken Ikehara[1] (1.Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HQR05-02] The Diatom Assemblages as the Indicators for Huge Tsunami Sedimentations and Recover Processes of Environment at Kesennuma Bay, Tohoku, Japan

*Kaoru Kashima[1], Ryozo Shiomi, Yu Fukumoto[3], Tsuyoshi Haraguchi[2] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Department of Geosicneces, Graduate School of Science, Osaka City University, 3.Ritsumeikan University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HQR05-03] **Niger Delta dynamic phase in the Gulf of Guinea during the last 20 ka: Panacea for the sustainable development of the region**

*Onema Christopher Adojoh[1], Marret-Davies Fabienne[2], Tetsuji Muto[3] (1.Missouri Univetrsity of Science and Technology, Rolla, USA, Dept of Geoscience, Geological and Petroleum Engineering, 1400 North Bishop, Post Code 65401, 2.School of Environmental Sciences, University of Liverpool, L69 7ZT, UK, 3.Nagasaki University, Japan, Dept of Environmental Science and Fisheries, 1-14 Bunkyomachi, Nagasaki, 8528521)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HQR05-04] K-feldspar post-IR IRSL ages suggest the presence of MIS 5a–c marine terraces in the eastern margin of the Kanto Plain, central Japan

★Invited Papers

*Toru Tamura[1,2], Hiroko Okazaki[3], Hiroomi Nakazato[4], Tomonori Naya[1], Rei Nakashima[1] (1.Geological Survey of Japan, AIST, 2.Graduate School of Frontier Sciences, University of Tokyo, 3.Natural History Museum and Institute, Chiba, 4.National Agriculture and Food Research Organization)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HQR05-05] Tephrostratigraphy of drilled core C9010E off the Boso Peninsula: as a preliminary report

*Kaori Aoki[1], Makoto Kobayashi[1], Masanori Murata[1], Takehiko Suzuki[1] (1.Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HQR05-06] Late Quaternary fluvial terraces and piracies in the Tanagura area, along the upper reaches of Kuji River, NE Japan

*Yuichi Kato[1], Takehiko Suzuki[1] (1.Graduate school of Urvan Environmental Sciences, Tokyo Metropolitan University)

Disturbance of sea floor by large earthquake and formation of earthquake-induced event deposit: Where is a suitable location for deep-sea turbidite paleoseismology

*Ken Ikehara[1]

1. Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology

Surface sediment remobilization is a relatively new idea for generating earthquake-induced fine-grained turbidites. It is important for repeated deposition of fine-grained turbidite by every earthquake to deposit enough amounts of sediments, which are resuspend and redeposit by the next earthquake, on the slope. Remobilized sediment may move downslope gravitationally, and deposit in a depression at the base of slope. Sediment accumulation between earthquake events should be large enough for distinguishing each event deposits (fine-grained turbidites). Thus, the basin at the foot-of-slope with high sedimentation rate is a suitable location for deep-sea turbidite paleoseismology.

Keywords: turbidite, paleoseismology, surface sediment remobilization

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The Diatom Assemblages as the Indicators for Huge Tsunami Sedimentations and Recover Processes of Environment at Kesennuma Bay, Tohoku, Japan

*Kaoru Kashima[1], Ryozo Shiomi, Yu Fukumoto[3], Tsuyoshi Haraguchi[2]

1. Department of Earth and Planetary Sciences, Kyushu University, 2. Department of Geosicneces, Graduate School of Science, Osaka City University, 3. Ritsumeikan University

Kesennuma Bay is located north of Sendai, Miyagi Prefecture, and is an enclosed bay along the Pacific Ocean. It was damaged by the Tsunami at 2011 East Japan Tsunami (March 11, 2011). About 1500 persons were killed and 10,000 houses were broken by the tsunami along the bay. The oil from the broken oil flowed into the bay, and fired for several days at the north part of the bay. The oil fire left the serious influences for the plankton flora, and took huge damage for the fishery production of the bay for several years.

The tsunami currents occurred huge scale of sedimentation and erosion within the bay. Dr. Tsuyoshi Haraguchi, Osaka City University, compared the detail measurements of the submarine topography of the bay between in 2010 (one year before the tsunami), 2011 (one month later the tsunami) and in 2013 (two years later the tsunami) and presumed the distributions of erosion and deposition areas in the bay by the tsunami current. The maximum sedimentation by the tsunami current reached more the 3m, at north and east part of the bay. He also took core samplings of the tsunami deposits where the sedimentary parts, and made clear that almost of the tsunami deposits were consisted of clay or silt materials. The sand material (the Tsunami Sand) distribution was very limited in the bay (the margin of the bay).

Diatom are clay or silt size (less than 100 μm), and we tried to trace the transportation processes by the tsunami of silt and clay materials using diatom assemblages in the sediments. The samples for diatom analysis in the Kesennuma Bay were as follows:

(a)The surface deposits at 26 sites in the bay, taken in 2010 (one year before the tsunami), in 2012 (one year after the tsunami) and in 2014 (three years after the tsunami)
(b)Three drilling cores at the tsunami deposits in the bay taken in 2013 (two years after the tsunami).
(c)Three drilling cores at the Tsunami deposits at 1960 Chilli Tsunami (1960 Valdivia Earthquake Tsunami) taken 2009, two years before the 2011 Tsunami.

At the tsunami currents in 2011, a lot of inland deposits along the coasts flowed into the bay by the back current of the tsunami. The ratio of the freshwater diatom assemblages in the bay surface deposits increased about 50%, and it presumed the strong sedimentation of freshwater materials from inland coasts by the tsunami.

The 1960 Chilli Tsunami (1960 Valdivia Earthquake Tsunami) had long-period waves (about 100 minutes interval). The waves looked gently moved on the surface, but the strong erosion and sedimentation processes were occured at the submarine floor of the bay.

The fluctuations of “go” and “back” currents of tsunami were kept as the laminated structures in the core deposits in the bay clearly. Diatom assemblages also fluctuated according to the laminated

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structures. Ratio of off shore marine diatoms increased at the “go” stages, and freshwater diatoms from inlands increased at the “back” stages.

Keywords: Diatom Assemblages, 1960 Valdivia Earthquake, 2011 Earthquake off the Pacific Coast of Tohoku, Kesenunuma Bay, Submarine Topography

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Niger Delta dynamic phase in the Gulf of Guinea during the last 20 ka: Panacea for the sustainable development of the region

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The Niger Delta is ideally located in a region of great sensitivity to climate change and sea level fluctuations and offers the possibility to provide insights on Late Quaternary environmental change in Equatorial West Africa. In comparison with other major tropical deltas, this deltaic system’ s response to past climate change and sea level fluctuations during the last 20 ka is poorly understood due limited studies in the basin. This presentation documents the detailed analyses of a multi-proxy dataset collected from three gravity cores obtained from the shallow margin of the Niger Delta to fill this scientific knowledge gap. The dataset included sedimentology, grain size, geochemistry, calcareous nannoplankton, foraminifera, and palynomorphs. The study hypothesised that the dynamics of the Intertropical Convergence Zone (ITCZ) and sea level fluctuation played a major role in shaping the landscape in the Niger Basin and adjacent coastal regions.

The palynological sequences defined in the three gravity cores show very similar fluctuations; afromontane forest (Podocarpaceae), freshwater swamp (Cyperaceae), savannah (Poaceae) and lowland rainforest (Polypodiaceae) dominated the late glacial and deglaciation periods, followed by the development of mangrove vegetation (Rhizophoraceae) during the interglacial in Early to mid-Holocene. These records suggest dry conditions and lower sea level during the late glacial and deglaciation periods, and warm conditions leading to the rise of the sea level during the interglacial.

The two stages of evolution at different periods has resulted in an improved understanding of the paleoenvironmental dynamics for the sustainable development of the region.

Keywords: Niger Delta, Deltaic Environment, Late Quaternary, Sustainable Development

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K-feldspar post-IR IRSL ages suggest the presence of MIS 5a–c marine terraces in the eastern margin of the Kanto Plain, central Japan

*Toru Tamura[1,2], Hiroko Okazaki[3], Hiroomi Nakazato[4], Tomonori Naya[1], Rei Nakashima[1]

1. Geological Survey of Japan, AIST, 2. Graduate School of Frontier Sciences, University of Tokyo, 3. Natural History Museum and Institute, Chiba, 4. National Agriculture and Food Research Organization

There has been a long-standing question about the Late Quaternary tectonics of the Kanto Plain nearby the triple junction of the plate boundaries. The Last Interglacial (MIS 5e) raised marine terrace has been widely correlated over the Kanto Plain and supposed to represent a general uplift trend associated with local variations. However, a thick accumulation of Quaternary sediments indicates the Kanto Plain had been subsided in the longer-term, and it is unclear when and how the recent uplift trend started. Fragmentary evidences have been recently presented for revising the tectonic history of the Kanto Plain. In the Iioka Plateau, at the eastern end of the plain, a part of the marine terrace formerly correlated with the MIS 5e was constrained to have ages of the MIS 5a or 5c by the composite chronology. As sea levels in the MIS 5a and 5c were much lower than MIS 5e, this revision poses a question about the consistent uplift of the Kanto Plain since the MIS 5e.

K-feldspar post-IR IRSL (pIRIR) ages are presented here to examine the marine terrace in the Kashima Plateau, eastern Kanto Plain, which has also been exclusively correlated as the MIS 5e. The sediment succession of the Kashima Plateau is characterized by marine to brackish deposits with pIRIR ages of the MIS 7 or 9, overlain by the succession of shallow-marine deposits. The shallow-marine succession is variable; in the landward section it is exclusively fine to medium sands overlain by a several meters thick aeolian unit, while the seaward section is gravelly coarse sands with negligible aeolian capping. This variation is corroborated with pIRIR ages. The landward and seaward sections are dated as 137±14 to 155±12 ka, and 86±9 to 105±8 ka, respectively. pIRIR ages are likely to be overestimated by several thousand to ten thousand years. Therefore, the Kashima Plateau represents a composite marine terrace that is correlated with the MIS 5e and MIS 5a or 5c in the landward and seaward sections, respectively. Along with the Iioka Plateau, this composite marine terrace occurs throughout the eastern margin of the Kanto Plain, which requires the Late Pleistocene tectonic history of the Kanto Plain to be reconsidered.

Keywords: OSL dating, Quaternary, Kanto Plain

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Tephrostratigraphy of drilled core C9010E off the Boso Peninsula: as a preliminary report

*Kaori Aoki[1], Makoto Kobayashi[1], Masanori Murata[1], Takehiko Suzuki[1]

1. Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University

We investigate the history of volcanic activities in north Izu Islands, and try to establish the high-resolution tephrochronology (Aoki *et al.,* 2019). Today, we present a part of the result of tephra correlations intervening in the sediment core off the Boso Peninsula, on the basis of the geologic, petrographic and geochemical characters of tephra samples collected at the reference sites on land. The sedimentary core C9010E was drilled at the site (34˚33.46'N, 139˚53.38'E, water depth: 2027.25 m) of about 40 km south of Boso Peninsula by the D/V *Chikyu* in 2009. The length of all core is 190.38 m. We collected 314 samples for tephra analysis from this core, including 161 tephra samples described (Tsuchiya *et al.*, 2009). The major-element chemistry of volcanic glass shards in the fraction of 63-125 μm for all samples have been determined by EPMA of the Center for Advanced Marine Core Research, Kochi University.

Firstly, all samples were checked roughly, and some fine glassy samples which might be correlated to widespread marker tephras were picked up and analyzed. As a result, correlatives for Aso-4 (87.1 ka; Aoki, 2008) at the depth 149.08 mbsf, On-Pm1 (95.7 ka; Aoki *et al.*, 2008) at 158.244 mbsf, and Aso-ABCD at 25 cm below On-Pm1 were found, respectively. Secondly, it is summarized the result of analysis for 28 samples (No.1~28) from the top of core to approximately 30 mbsf. Ten samples consist of mainly scoria clasts. Another 20 samples are rich in felsic volcanic glass shards, and including plagioclase, quartz (including beta-quartz), orthopyroxene, hornblende, cummingtonite, and occasionally biotite. The content of SiO_2 in felsic volcanic glass shards is 77.9-78.8 wt% generally, and it is so much. Except No.18 (16.722-16.772 mbsf), the contents of FeO* (0.59-0.74 wt%) and CaO (0.34-0.70 wt%) in felsic volcanic glass shards are remarkably low, on the other hand, the contents of Na_2O (4.12-4.25 wt%) and K_2O (3.45-4.15 wt%) are relatively high. These characters of major-element composition are resembled to them of felsic tephras provided from Niijima and Kozushima during late Quaternary. Furthermore, we tried to correlate each tephra bed in the core C9010C to each eruptive event based on the major-element composition. The probabilities that No.1 (1.15-1.17 mbsf) as the highest layer correlates to Niijima Mukaiyama tephra (AD886), and No.2 (1.63-1.66 mbsf) correlates to Kozushima Tenjyosan tephra (AD838) are high. No.8 (9.36-9.48 mbsf), No.12 and No.13 (14.32-14.65 mbsf), and No.14, No.15 and No.16 (No.14.65-15.54 mbsf) will correlate to the eruptive events of Miyatsukayama SW, Shikinejima, and Miyatuskayama on the Niijima main island, respectively (Kobayashi *et al.*, 2019a). The petrographic and geochemical characters of No.19 and No.20 (19.90-19.00 mbsf), No.21 (19.31-19.34 mbsf), and No.28 (29.49-30.66 mbsf) are resemble to the events of Akasakimine on Niijima main island. There are hemipelagic ooze of 11 m thick, including several scoria layers, between No.19 and No.28. Kobayashi *et al.* (2019a) report Akasakimine events are several eruptions at ca.15-20 ka, therefore it would make sense for the time interval of 11 m-thick sediment between No.19 and No.28. Above-mentioned correlatives to tephras provided from Niijima island consists of felsic volcanic glass shards mainly, only a small amount of scoria grains is included. No.18 (16.72-16.78 mbsf) is sorted glassy tephra mainly, with gray to beige fine bubbled pumices, which maximum diameter is 7 mm. There are almost volcanic glass shards including a small amount of plagioclase, quartz and orthopyroxene, not scoria grains and lithic fragments in the fraction of 63-250 μm. The content of SiO_2 is 78.8 wt%, FeO* is 1.24 wt%, CaO is 1.25 wt%, Na_2O is 4.76 wt%, and K_2O is 1.22 wt%. We consider that No.18 would be correlated to tephra provided from the submarine volcano Oomurodashi at 13.4 ka (Hamuro *et al.*, 1983; Saito and Miyairi, 2008; Tani *et al.*,

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2017).

Keywords: CK09-03, C9010E, late Quaternary, Niijima, Kozushima, Oomurodashi

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Late Quaternary fluvial terraces and piracies in the Tanagura area, along the upper reaches of Kuji River, NE Japan

*Yuichi Kato[1], Takehiko Suzuki[1]

1. Graduate school of Urvan Environmental Sciences, Tokyo Metropolitan University

In the Tanagura area, the upper reaches of Kuji River and the Yashiro River (a tributary of the Abukuma River), both river basins are in contact with each other. In this area, landforms showing piracies by the Kuji River exist. Previous studies have also suggested the occurrence of capturing. However, ages of piracies have not yet been determined. For determination of ages occurring piracies, chronology of terraces was established in the Tanakura area.
In this area, three landforms showing piracies exist. Timing of occurring piracies can be divided into two. In this paper, we named three paleo-rivers captured by Kuji River, that is, Ko-Uwadai River captured in the former and Ko-Mukaihara River and Ko-Shimohabara River in the later.
Fluvial terraces formed with the base level of erosion by the Abukuma River are classified into Yashiro River High terrace (YH), ditto Middle 1 terrace (YM1), ditto Middle 2 terrace (YM2) in descending order. Those by Kuji River are classified into Kuji River High 0 terrace (KH0), ditto High 1 terrace (KH1), ditto High 2 terrace (KH2), ditto Middle 0 terrace (KM0), ditto Middle 1 terrace (KM1), ditto Middle 2 terrace (KM2), ditto Low 0 terrace (KL0), ditto Low 1 terrace (KL1) and ditto Low 2 terrace (KL2) in descending order. YH formed by Ko-Uwadai River and YM2 by Ko-Mukaihara River and Ko-Shimohabara River displays characteristic topographies that indicate piracies.
KM1 consists of terrace deposits with a thickness of 2 m was covered with a tephric loess of which thickness is 3 m. This tephric loess includes AT tephra (30 ka) just above flood loam. Therefore, it is concluded that KM1 was formed at shortly before 30 ka.
KM2 consists of terrace deposits with a thickness of ca 4 m, and tephric loess or sediment covering terrace deposits was not recognized. Terraces identified as KM2 are broadly distributed in transitional zone from mountain to major valleys, terrace gravels of KM2 are coarser and are not well sorted. This suggests KM2 gravel have been deposited under the glacial stage environment. Because glacial stage after the deposition of AT is only MIS2, KM2 gravel have been deposited in 20–15 ka.
KL1 consists of terrace deposits consisted of sub-rounded gravels with a thickness of 1–2 m. There is no tephric loess on this gravel bed. KL1 where the last stage of the Jomon Period site situated on is younger than KM2. This show that KL1 was emerged at 15 ka to 2 ka.
YH consists of terrace sediment with a thickness of 4 m and it is covered by tephric loess of 8 m in thickness. This tephric loess includes two scoria fall deposits possibly correlated to be one of Ns-Sr6 (150 ka) to Ns-Sr12 (200 ka). Considering the age of YH, that is 150–200 ka.
YM2 consists of terrace sediment with a thickness of 2–3 m. Tephric loess or this sediment was not recognized. It seems that there is no tephric loess or at most 1 m in thickness. Geology and landform of YM2 is similar to those of KM2. This show that these terraces have been formed simultaneously. Considering the emergence of YM2 with piracy by Kuji River basin, the age of YM2 is around 20–15 ka.
Then, we consider when these piracies were occurred. Considering Ko-Uwadai river, the older limit of age in capturing is the formation of YH. YH would have been dissected by valley formed in an interglacial epoch, however, there is no valley. This suggests piracy occurred in MIS6 to MIS5e (200–125 ka).
Considering Ko-Mukaihara River and Ko-Shimohabara River, the older limit of age in capturing is the formation of YM2. In addition, the younger limit is KL1 because profiles of tributaries of Kuji River formed by capturing Ko-Shimohabara River are continual to KL1. Thus, piracy probably occurred in 20–2 ka.
Both piracies were occurred in glacial stage to interglacial stage condition. In conclusion, these piracies

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occurred under the influence of climate change.

Keywords: Kuji River, Yashiro River, fluvial terrace, piracy

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[J] Oral | H (Human Geosciences)：H-QR Quaternary research

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 102 1F

[H-QR05] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Masayuki Hyodo(Research Center for Inland Seas, Kobe University), Chairperson:Mamoru KOARAI(Ibaraki University), Tomonori Naya(産業技術総合研究所)

Humans have attained their specific development by indigenous cultures and evolved through environmental adaptation. The session raises issues of human-environmental interactions, views from diverse changes of climate, ocean, land and biota having made striking influence on humans. It welcomes various fields from human-environment change and their chronometric dating among Quaternary disciplines.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[HQR05-07] Landform features of Okinoshima of Munakata city

*Takahito Kuroki[1] (1.Faculty of Education, Univ. of Teacher Edu. Fukuoka)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[HQR05-08] Revision of geomorphology and geology of Tokyo Upland and Lowland, based on boring data and precise landform analysis

★Invited Papers

*Kunihiko Endo[1], Yusuke Suginaka[2], Shinzaburo Hori[2], Toshihiko Sugai[3], Takehiko Suzuki[4], Shigeko Ishiwata, Yo Uesugi, Reisuke Kondo[5], Tatsuro Chiba[6], Toshio Nakayama[7], Shigeto Osato[8], Marie Noguchi[9], Akio Sato[3], Takato Takemura[10] (1.Nihon University, 2.Research Center of Computational Mechanics, Inc., 3.Graduate School of Frontier Science, The University of Tokyo, 4.Faculty of Urban Environmental Sciences, Tokyo Metropolitan University, 5.Educational Development Center, Kogakkan University, 6.Asia Air Survey, 7.Civil Engineering Support & Training Center, Tokyo Metropolitan Government,, 8.Doshitsu Research Corporation, 9.Paleo Labo co.,ltd., 10.College of Humanities and Sciences, Nihon University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[HQR05-09] Sedimentological characteristics of the Ome Formation exposed on the western margin of Musasino Upland, central Japan

*Takako UTSUGAWA[1], Masaaki Shirai[2], Hiroka Kato[2], Sayuri Kato[3] (1.Department of Geography, Rissho University, 2.Department of Geography, Tokyo Metropolitan University, 3.Hamura City)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[HQR05-10] Stratigraphy of Tokyo Formation: re-examination of Kita-Ku Central Park core

*Tomonori Naya[1], Kentaro Sakata[1], Tsutomu Nakazawa[1], Takehiko Suzuki[2], Toshio Nakayama[3] (1.Geological Survey of Japan, AIST, 2.Tokyo Metropolitan University, 3.Tokyo Metropolitan Government)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[HQR05-11] S-wave veolocity structure and ground motion characteristics of "loam terraces": Examples from the eastern part of Utsunomiya City, Tochigi Prefecture, central Japan

★Invited Papers

*Tsutomu Nakazawa[1], Ikuo Cho[1], Kentaro Sakata[1] (1.Geological Survey of Japan, AIST)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[HQR05-12] The relationship between liquefaction distribution and microtopography classification during the 1948 Fukui earthquake - Toward improvement of liquefaction hazard map -

*Haruka Tani[1], Masanobu Shishikura[2] (1.Housei University, 2.Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology)

Landform features of Okinoshima of Munakata city

*Takahito Kuroki[1]

1. Faculty of Education, Univ. of Teacher Edu. Fukuoka

The Sacred Island of Okinoshima and Associated Sites in the Munakata Region was registered as a World Heritage in July 2017. Okinoshima located about 70 km northwest of Kyushu main island is a small island with maximum altitude above sea level of about 240 m and an area of about 960,000 m^2. The island consists of a steep cliff and gentle slope and the area of the plain is small. It consists of shale in the southwest part, quartz porphyry in the northwest part, and talus deposit in the southeast part, which has a unique landform distribution. Many historical relics were discovered and investigated there. Many precious votive offerings were conducted to pray for safety ocean voyages from the 4th to the 9th centuries and a sacred place, Okitsu-miya of Munakata Taisha is settled on the gentle slope on the south side of this island. Residents have unwritten taboos that forbid actions such as removing anything from the island, or revealing anything seen or heard there.
From the GIS analysis of various kinds of geographic information, I created maps of land and seabed of it and examined the features of the landforms. Furthermore, I carried out morphological and geological surveys on site. Fundamental geospatial data of GSI, map information related to isobaths of JHA and airborne laser scanner data of Munakata city are used as the geographic information. Basic ground elevation maps, slope maps, relief maps and 3D images were created. A landform classification map of land was made by interpretation of each basic map and field survey. Especially in the southwest part, the distribution of steep cliff and landslip lobe, which indicates the existence of landslides, is distinctive. In addition, the three groups of lineaments that trend west-southwest can be interpreted on the ground. From the 3D images etc., it can be identified that the altitude of Okinoshima is about 340 m above the flat seabed. The topography of seabed in the southern part of Okinoshima, is a shallow flat table in the west side and a concave area inclining to the east in the east side. Other landform features that should be investigated in the future are also confirmed in Okinoshima.
In this presentation, I would like to introduce features of the landforms clarified from the analysis of maps by GIS on Okinoshima where access is restricted.

Keywords: Okinoshima, map, landform, landslide

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Revision of geomorphology and geology of Tokyo Upland and Lowland, based on boring data and precise landform analysis

*Kunihiko Endo[1], Yusuke Suginaka[2], Shinzaburo Hori[2], Toshihiko Sugai[3], Takehiko Suzuki[4], Shigeko Ishiwata, Yo Uesugi, Reisuke Kondo[5], Tatsuro Chiba[6], Toshio Nakayama[7], Shigeto Osato[8], Marie Noguchi[9], Akio Sato[3], Takato Takemura[10]

1. Nihon University, 2. Research Center of Computational Mechanics, Inc., 3. Graduate School of Frontier Science, The University of Tokyo, 4. Faculty of Urban Environmental Sciences, Tokyo Metropolitan University, 5. Educational Development Center, Kogakkan University, 6. Asia Air Survey, 7. Civil Engineering Support & Training Center, Tokyo Metropolitan Government,, 8. Doshitsu Research Corporation, 9. Paleo Labo co.,ltd., 10. College of Humanities and Sciences, Nihon University

Musashino Uplands in Tokyo and the southern Saitama Prefecture, had been investigated by many researchers for the last 90 years. The uplands, with wide area of 45km E -W and 25km N-S, are composed of Musashino and Tachikawa alluvial fans of MIS 5c to MIS 3 and Shimo-sueyoshi marine terraces of MIS 5e, as a type area in the Late Quaternary in Japan.
Recently great advancement in technology changes the research condition also in geomorphology and Quaternary geology.
First, GSI digital elevation model of 5m, is recently opened to the public. It is strongly useful data and tools to analyze precise classification of landforms in densely-developed urban areas like Tokyo. It provides us new maps as Red Relief Map (designed by T. Chiba), new type erosion depth map (by T. Chiba), and Rainbow Color Contour Map (Suginaka et al., 2018), all of them contributed to make a new division of landforms in Musashino Uplands with accuracy of 1 meter.
Second, a great number of digitized boring data and analyzing tools have been opened to the public. We have used more than 50 thousands data in the Musashino Uplands and Tokyo Lowland. These data revealed the underground geology in shallow part (20 to 100 meters in depth) continuously.
Third, tephrochronological studies in southern Kanto Plain have been established. However, in Tokyo area, distant from the source volcanoes, tephra studies were not enough. Moreover, the studied sites located only at the margin of the uplands. Recent progress in tephrochronology brings us to analyze cryptotephra for the age determination of the older fan gravels of research boring cores at the important site of the fan surface.
Those three new research conditions enable us to renew the division of landforms in Musashino Upland and Tokyo lowland.
Fourth, we created a new system using an automated program analyzing geological sequence from a vast number of boring data.
Main characteristics of this approach is to combine new results of computer-supported geomorphological and shallow geological data, with field-based knowledge and analog-type analyses such as a number of geologic profiles.

Keywords: boring data, geomorphology and geology in Tokyo, landform division in Musashino Upland

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Sedimentological characteristics of the Ome Formation exposed on the western margin of Musasino Upland, central Japan

*Takako UTSUGAWA[1], Masaaki Shirai[2], Hiroka Kato[2], Sayuri Kato[3]

1. Department of Geography, Rissho University, 2. Department of Geography, Tokyo Metropolitan University, 3. Hamura City

The Ome Formation defined on the middle 20th century has not been understood enough due to various facies of the formation reported by previous studies and destruction of the outcrops by urbanization. We examined sedimentological characteristics of the Ome Formation distributed in Ome and Hamura cities, Tokyo, central Japan.

Musashino Upland, a large alluvial fan located in the southwestern part of Kanto Plain were formed by the Tama River (ca. 100-20 ka). Along the Tama River, multiple fluvial terraces have formed since the last interglacial (e.g., Ueki and Sakai, 2007). Juen (1964) reported a sandy conglomerate being distinguishable from the upper terrace deposits and the lower Onita (Kasumi) Formation in Kazusa Group, exposed at the terrace cliff along the Tama River. Based on the boring core investigation, it was revealed that the similar sediments have been buried under the western part of Musashino Upland (e.g., Yamazaki, 1978).

A surviving outcrop of the Ome Formation, 20 m thick clast-supported sandy conglomerate has exposed at the terrace cliff located around the boundary between Ome and Hamura cities. The formation is mainly composed by cobbles (5-20 cm in diameter). Boulders (20-40 cm in diameter) make channel-like structures in the basal part of the formation. Microscopic observation revealed that shale fragments were abundant as much as sandstone fragments. Sandstone gravels were the major component followed by chert and shale gravels derived from the Kanto Mountains (accretionary complex). Weathered granitoid gravels were also a few included.

The ratio of chert gravel in the Ome Formation shows downward increase. Chert gravel abundance of the basal Ome Formation is almost equal to one of the Onita Formation, it may imply that hard and durable chert gravels composing the Onita Formation had been reworked and included in the basal Ome Formation. The averaged imbrication of gravels of the Ome Formation indicated NNW direction. It means that the palaeocurrent was similar with the present Tama River current.

Ueki and Sakai (2007) hypothecated that Ome Formation is an aggregation of multiple channel deposits during several interglacial-glacial periods. Based on the sedimentological characteristics of Ome Formation as described above and the established boring core information, we also estimated the distribution of Ome Formation buried around the western part of Hamura City.

Acknowledgement
A part of this study is supported by Municipal history compilation office in Hamura-city (2014-2018).

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Municipal history compilation office in Hamura-city. 2019. *The book of materials –Nature– in Hamura-city*

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Yamazaki, H. 1978. *The Quaternary Research* 16: 231-246. (in Japanese with English abstract)

Keywords: Ome Formation, Tama River, imbrication, gravel, buried valley, Musashino Upland

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Stratigraphy of Tokyo Formation: re-examination of Kita-Ku Central Park core

*Tomonori Naya[1], Kentaro Sakata[1], Tsutomu Nakazawa[1], Takehiko Suzuki[2], Toshio Nakayama[3]

1. Geological Survey of Japan, AIST, 2. Tokyo Metropolitan University, 3. Tokyo Metropolitan Government

We re-examined the Kita-ku Central Park core to examine the stratigraphy of Tokyo Formation. Several depositional cycles consistent with gravels, sands and mud were observed at shallower than the depth 30 m of this core. A pumice layer was found at about 15 m depth of this core, which can be correlated with Km2 tephra of the Kamiizumi Formation of Shimosa Group, suggesting that the Middle Pleistocene sediments corresponding to MIS 7e is distributed in shallow subsurface at this area.

Keywords: Tokyo Formation, stratigraphy, drill core

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S-wave veolocity structure and ground motion characteristics of "loam terraces": Examples from the eastern part of Utsunomiya City, Tochigi Prefecture, central Japan

*Tsutomu Nakazawa[1], Ikuo Cho[1], Kentaro Sakata[1]

1. Geological Survey of Japan, AIST

S-wave velocity structure and ground motion characteristics of “loam terraces” are examined in the eastern part of Utsunomiya City, Tochigi Prefecture, northern Kanto Plain, central Japan. The microtremor array observations reveal that the average S-wave velocitity in the upper 30 m (AVS30) becomes lower and the peak frequency in the H/V spectrum sifts to the lower value in higher terraces. These are considered to be influenced by the thickness of the loam bed (S-wave velocity: ~150 m/s) covering gravelly terrace deposits. We should note that the relatively low frequency (1.5–2 Hz) ground motion would be more largely amplified in the higher terraces and hills compared with the lower terraces.

Keywords: S-wave velocity structure, ground motion characteristics, loam terraces, microtremor array observation, Utsunomiya City, Kanto Plain

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The relationship between liquefaction distribution and microtopography classification during the 1948 Fukui earthquake - Toward improvement of liquefaction hazard map -

*Haruka Tani[1], Masanobu Shishikura[2]

1. Housei University, 2. Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology

Introduction
In most of the cases of recent large-scale natural disasters, it seems that the present hazard maps cannot have forecasted its damages precisely (Wakamatsu et al., 2017; Une et al., 2015). This is because the specific method for establishing a hazard map is not defined nationally and it is entrusted to each local government. For further disaster prevention and reduction, it is important to establish a more reliable hazard map with a low cost and simple method. Forecast of liquefaction occurrence from a geomorphological point of view can respond to such demand. Nakao et al. (2015) proposed a method for creating a liquefaction hazard map based on the liquefaction hazard evaluation criteria and corresponding geomorphic classification from past liquefaction cases in the Kanto region. However, even in regions other than the Kanto region with different geomorphic development histories, it is not certain whether these criteria are effective. This study treats the case of the liquefaction caused by the 1948 Fukui earthquake (M 7.1) in the central part of Fukui City and examines the issues of present hazard map. Then we would like to propose the direction for creating more precise liquefaction hazard map.

Method
To clarify the liquefaction distribution of the Fukui earthquake, I obtained old air-photographs of the survey area taken by GHQ immediately after the earthquake published by the Geospatial Information Authority Japan (GSI). This study independently defined the criteria of air-photo interpretation to identify the traces of liquefaction. The results of air-photo interpretation were drawn on the map by vector data using QGIS and compared to present hazard map and various geomorphic classification maps published by GSI.

Results and Discussion
Comparison results of the liquefaction distribution of the 1948 Fukui earthquake revealed from air-photo interpretation in this study with various maps suggest that the geomorphic classification defined by Nakao et al. (2015) can apply to this study area. And also our results can newly propose some geomorphic features relating to liquefaction. For example, liquefaction occurred intensively near the old artificial bank overlapped with the former river channel, and also old bank at the adjacent point with the natural levee located on the outer shore of the former meandering river. Because beneath such areas are composed of thick loose sand, liquefaction can easily occur and geomorphic condition triggered lateral flow.
From the above results, it can be regarded that the risk of liquefaction occurrence varies depending on the combination with surrounding microtopography. Therefore, consideration of microtopography is indispensable for establishing liquefaction hazard map.
The liquefaction hazard map of Fukui City is hardly consistent with the liquefaction distribution due to the 1948 Fukui earthquake and does not reflect the actual liquefaction risk, because the present hazard map does not only refer to liquefaction history but also does not consider microtopography.For more precise forecast the liquefaction damages, we propose that the liquefaction hazard map should be established by

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considering liquefaction history and microtopography.

Remained Issues
Because this study uses old black and white air-photographs, there is some difficulty part to detect details of liquefaction. To reveal the relationship between the liquefaction distribution and microtopography, it is necessary to conduct a field survey and interview to victims. The relationship between the distance from the seismic source of the 1948 event and the reaction of each microtopography is not yet resolved because this study focused on only in the central part of Fukui City. Therefore, it is also necessary to conduct air-photo interpretation in whole areas of the liquefaction damage caused by the 1948 event.

Keywords: 1948 Fukui Earthquake, liquefaction , microtopography classification, liquefaction hazard map

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[J] Poster | H (Human Geosciences)：H-QR Quaternary research

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_9

[H-QR05] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Masayuki Hyodo(Research Center for Inland Seas, Kobe University)

Humans have attained their specific development by indigenous cultures and evolved through environmental adaptation. The session raises issues of human-environmental interactions, views from diverse changes of climate, ocean, land and biota having made striking influence on humans. It welcomes various fields from human-environment change and their chronometric dating among Quaternary disciplines.

[HQR05-P01] Local marine reservoir age variability at Luzon Strait and Ryukyu Islands during the Holocene

*Shoko Hirabayashi[1,2,3], Yusuke Yokoyama[2,3], Atsushi Suzuki[4], Tezer Esat[5], Yosuke Miyairi[2], Takahiro AZE[2], Fernando Siringan[6], Yasuo Maeda[7], Hironobu Kan[1] (1.Graduate School of Social and Cultural Studies, Kyushu University, 2.Atmosphere and Ocean Research Institute The University of Tokyo, 3.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 4.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 5.Research School of Physics and Engineering, The Australian National University , 6.Marine Science Institute, University of the Philippines, 7.Institute of Natural and Environmental Sciences, University of Hyogo)

[HQR05-P02] Holocene sea-level and paleoenvironmental reconstruction using radiocarbon local marine reservoir age and geophysical modeling in Tongatapu, Kingdom of Tonga

*Naoto Fukuyo[1,2], Anthony Purcell[3], Geoffrey Clark[4], Phillip Parton[4], Yusuke Yokoyama[1,2], Yosuke Miyairi[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Department of Earth and Planetary Sciences, Faculty of Science, University of Tokyo, 3.Research School of Earth Sciences, The Australian National University, 4.College of Asia and the Pacific, Australian National University)

[HQR05-P03] The environmental change from lagoon sediment along Nakai Trough in Japan during the past 2000 years.

*Cho Ara[1], Kaoru Kashima[1], Jonathan D Woodruff[3], Koji Seto[2], Kazuyoshi Yamada[4], Kota Katsuki[2], Takumi Sato[2], Caroline Ladlow[3] (1.Kyushu University, 2.Shimane University, 3.University of Massachusetts, 4.Museum of Natural and Environmental History)

[HQR05-P04] Discovery and these sources of drift pumices interbedded in coastal sediments at Sekinehama, in the northern part of Shimokita peninsula, Aomori prefecture

*Reona Hiramine[1], Kaori Aoki[2], Daisuke Ishimura[1,2], Makoto Kobayashi[2] (1.Department of Geography, Tokyo Metropolitan University, 2.Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University)

[HQR05-P05] Comparison of geological stratigraphy between three drilling cores and analysis of shallow geological structure in the Koriyama Basin, Northeast Japan

*Takeshi ISHIHARA[1], Takehiko Suzuki[2] (1.Advanced Industrial Science and Technology, 2.Tokyo Metropolitan University)

[HQR05-P06] Holocene geomorphic development of the Kinu river system constrained by the dissected river valleys formed after MIS 5.

*Taiga Kimori[1], Toshihiko Sugai[2] (1.The University of Tokyo,Graduate School of Frontier Sciences,Dept. of Natural Environmental Studies, 2.The University of Tokyo)

[HQR05-P07] Depositional stratigraphy based on XRF, tephras and particle size analysis of core drilled in the central part of the Kanto plain, Sakai town, Ibaraki prefectural and Kuki city, Saitama prefecture (preliminary report)

*Tatsuki Miyamoto[1], Toshihiko Sugai[2], Kunihiko Endo[3], Natsuki Sasaki[2], Marie Noguchi[4], Sayuri Mitsuhashi[5] (1.Department of Earth and Planetary Environmental Science, The University of Tokyo, 2.Department of Natural Environmental Studies, Institute of Environmental Studies, Graduate School of Frontier Science, The University of Tokyo, 3.Nihon University, 4.Paleo Labo co.,ltd., 5.the Tone River Upstream River Office)

[HQR05-P08] Spatial distribution of Musashino Gravel in Tokyo using an automated program analyzing geological sequence from a vast number of boring data.

*Suginaka Yusuke[1], Kunihiko Endo[2], Shigeko Ishiwata, Toshihiko Sugai[3], Tatsuro Chiba[4], Taro Funatsu[3], Toshio Nakayama[5], Shinzaburo Hori[1] (1.Research Center of Computational Mechanics, Inc., 2.Nihon University, 3.Department of Natural Environmental Studies, Institute of Environmental Studies, Graduate School of Frontier Science, The University of Tokyo, 4.Asia air survay , 5.Tokyo metropolitan)

[HQR05-P09] Sedimentological features of Fuji-Sagamigawa Lahar deposits from the upper reaches of Sagami River, central Japan

*Masaaki Shirai[1], Mika Takehara[2], Takako UTSUGAWA[3] (1.Tokyo Metropolitan University, 2.Hachioji-City Office, 3.Rissho University)

[HQR05-P10] Terrace classification and geomorphological development process around Shinano river and Uono river junction area in Niigata prefecture

*Koseki Toshifumi[1], Mamoru Koarai[1] (1.Department of Earth Sciences, College of Science, Ibaraki University)

[HQR05-P11] Estimation of the Source of Sand Beach Sediment in Tsuruga Bay, Fukui Prefecture: Focusing on Grain Size Analysis and Composition of Clastics

*Akiko MATSUMOTO[1], Kiyokazu KAWAJIRI[2], Sumiko KUBO[1] (1.School of Education, Waseda Univ., 2.Sagamihara City Museun)

[HQR05-P12] Characteristics of Latest Pleistocene to Holocene deposits of two cores obtained from the inner part of the Nobi Plain, central Japan

*Kodai Hasada[1] (1.Faculty of Letters, Hosei University)

[HQR05-P13] Subsurface distribution of marine deposits during the MIS 5e and vertical displacement inferred from microfossil evidences and borehole logs in northern Ise Plain, central Japan

*Yoshiki Sato[1] (1.Advanced Industrial Science and Technology, Geological Survey of Japan)

[HQR05-P14] Detection of the Amagi-Kawagori tephra (Kg) in the Shijima lowland, the Shima Peninsula, and its significance to reconstruct tsunami history

Saki Yoshida[1], *Masanobu Shishikura[2], Hideaki Maemoku[1], Shigehiro Fujino[3] (1.Hosei University, 2.Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology, 3.University of Tsukuba)

[HQR05-P15] Holocene paleoenvironmental changes based on biomarker analysis at the western part of the Kawachi plain, Osaka, Japan

*Yukiko Ishino[1], Hideto Nakamura[1], Muneki Mitamura[1] (1.Osaka City University)

[HQR05-P16] Environmental change before and after Kikai-Akahoya tephra descent in the Miyazaki plain, Southern Kyushu

★Invited Papers

Mitsuhiro Kuwahata[2,7], Tatsuro Adachi[2], Yoshinori Tajiri[2], *Futoshi Nanayama[1,8], Shinji Sugiyama[6], Nakanishi Toshimichi[3], Ken'ichi Ohkushi[5], Tatsuhiko Yamaguchi[4] (1.Geological Survey of Japan, AIST, 2.Kyushu Univ., 3.Kyoto Univ., 4.Kochi Univ., 5.Kobe Univ., 6.Paleoenvironment Research Center Co. Ltd., 7.School board of Miyakonojyo City, 8.CWMD, Kumamoto University)

[HQR05-P17] The history of volcanic eruption based on tephrochronology at Plio-Pleistocene in Japan :2 Chronology of pyroclastic flow deposits in southern Kyushu

*Itoko Tamura[1], Kiyohide Mizuno[2] (1.Department of Geography,Graduate School of Urban Environmental Science,Tokyo Metropolitan University, 2.Research Institute of Geology and Geoinformation, Geological Survey of Japan, AIST)

[HQR05-P18] Identification of Ks5 tephra and similar tephras based on trace element composition of volcanic glass shards

*Hiroomi Nakazato[1], Futoshi Nanayama[2], Hisatoshi Ito[3], Shimpei Uesawa[3], Akira Furusawa[4], Kiyohide Mizuno[2] (1.National Agriculture and Food Research Organization, 2.National Institute of Advanced Industrial Science and Technology, 3.Central Research Institute of Electric Power Industry, 4.FURUSAWA Geological Survey)

[HQR05-P19] **Climate, vegetation and fire history of the last ~100 ka from archaeological sites of Belan valley, north-central India**

*Deepak Kumar Jha[1], Rahul Samrat[1], Prasanta Sanyal[1] (1.Department of Earth Scienes, Indian Institute of Science Education and Research Kolkata, Mohanpur -741246, India)

Local marine reservoir age variability at Luzon Strait and Ryukyu Islands during the Holocene

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The local marine reservoir age (ΔR) varies not only spatially, but also temporally because of changes in ocean circulation associated with climatic changes. Holocene ΔR values have mainly been reported from the South Pacific, while only a few spatio-temporal reconstructions of ΔR have been published in the western Pacific. Present day, short term variations in ΔR at the Ryukyu Islands, South Japan, were previously associated with variability in the El Nino-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). Further studies will better delineate this connection and establish the magnitude of the variability in ΔR in the western Pacific.

In this study, we measured high-resolution radiocarbon(^{14}C) ages and U/Th dates obtained from fossil corals on Luzon Island in the South China Sea (SCS) and Kikai and Kodakara Islands in Ryukyu Island Chain during the Holocene. A large ΔR variability of ~400 years was recorded at both Luzon Island and the Ryukyu Islands for the last 6000 years. An abrupt ΔR shift occurred between 5.5 ka BP and 4.0 ka BP in the northwest Pacific. Compared with the previously reported data from the Tropical East Pacific and Great Barrier reef, the timing of the shift was different because the ^{14}C content of the northwestern Pacific was affected by not only the intensity of upwelling at the Peru-Chile coast, but also by the East Asian monsoon.

This variability influences the calibration of local marine reservoir effect significantly when calibrating ^{14}C ages to calendar ages. High-resolution ^{14}C dating of marine samples became possible over the years, raising the need and importance of ΔR values to be reconsidered in high-resolution for different time periods.

Reference:

Hirabayashi et al. (2019) Local marine reservoir age variability at Luzon Strait in the South China Sea during the Holocene, *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, in press.

Keywords: U/Th dating, Radiocarbon dating, Local marine reservoir age, Corals

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Holocene sea-level and paleoenvironmental reconstruction using radiocarbon local marine reservoir age and geophysical modeling in Tongatapu, Kingdom of Tonga

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Reconstructing the history of Holocene relative sea levels around Tonga is important for understanding geomorphological theories and also interpreting paleoenvironmental and archaeological studies in that area. However, neither continuous sea level reconstructions nor quantitative paleoenvironmental studies using geochemical/physical methods are available. In this study, we reconstructed Holocene sea level changes in Tongatapu island using radiocarbon local marine reservoir age (ΔR) and glacio-hydro adjustment (GIA) modeling. Furthermore, we interpreted the relationship between the reduction of the size of bivalves (*Gafrarium tumidum*) and changes in their paleoenvironment. We suggest that ΔR results showed a sea surface salinity (SSS) decrease in the islands lagoon as relative sea level have been risen during the period between ~2.6 cal kyr BP to the present, and this can be attributed as closure of the lagoon. Moreover, the maximum sea level in mid-Holocene using GIA modeling suggest that contribution of hydro-isostatic rebound to sea level changes were much smaller than previously reported values. We infer that the current rate of vertical land motion reported from instrumental observations at Tongatapu is inconsistent with the Holocene sea level record, and must have been responsible from recent tectonic events. Comparing ΔR results with paleotopographical maps, we suggest that ΔR can record the response to subtle environmental changes that cannot be reconstructed in the model. We also suggest that there is a possibility that SSS is an environmental stress factor for the growth of *G. tumidum* in Tongatapu for the past 2600 years and that this is due to the closure of the lagoon by RSL changes supporting the implication reported previously from an archaeological study (Clark et al., 2015).

Keywords: Holocene, Southern Pacific, Paleoenvironment studies, Local marine reservoir effect, GIA modelling, Bivalves

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The environmental change from lagoon sediment along Nakai Trough in Japan during the past 2000 years.

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The lagoon sediment offers critical information for sea level change because lagoon reacts sensitively with a small fluctuation of sea level. In other words, the environment change in lagoon depends on sea level fluctuation. The sediment in the lagoon in Japan was continuously deposited and offer high-resolution results such as paleoclimate change and sea level change. The environmental change was reconstructed from three lakes, Lake Hamana, Lake Kawahara, Lake Ryuuoo, based on diatom assemblage. The 16Hm-1C core was taken from Lake Hamana. The environment is divided based on diatom assemblage. Zone 1 is dominant by *Cyclotella atomus* and *C. atomus* var. *gracilis*. It is suggested that the lake was a hypersaline lake. Then the lake was changed to Oligohaline lake in AD 200. Zone 3 and Zone 4 were dominant with freshwater species. Around mid of 14th century, the lake was changed to the brackish lagoon as consequences of creating inlet and paleoriver activity. KAW2 core was from Lake Kawahara. Zone1 was typical lagoon which is affected by sea water. After around AD 550, the lagoon changed to the brackish lagoon. Freshwater species in AD 1100 dominated the lake. The RYU core got taken from Lake Ryuuoo. The environmental changed from brackish lagoon to freshwater lake in AD 600. The environmental change happened at the same time in 3 lakes. The coastal deformation resulted in change RSL (relative sea level) and environmental change in lakes.

Keywords: Lagoon, Diatom, Environmental change

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Discovery and these sources of drift pumices interbedded in coastal sediments at Sekinehama, in the northern part of Shimokita peninsula, Aomori prefecture

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Pumice, one of the pyroclastic materials, may start drifting in the sea for some reason and be carried to distal places by the tide. Pumice which started drifting is assumed to, lost its buoyancy due to the attachment of marine life or the filling of water in the pores, except the case that it is launched to the coast (Kato, 2009), and such pumice is called "drift pumice". Shiraishi et al. (1992) reported that drift pumices of Aso-4 pyroclastic flow deposits and Sambe-Kisuki pumice fall deposits existed in the upper Quaternary in Oga peninsula. In addition, 7 to 10 thousand years ago when Aso-4 and SK erupted, the possibility that there was an ocean current northward of the Sea of Japan was mentioned. Pumice drifts under the influence of topography and ocean current. Thus, drift pumice in the strata can be evidence of estimate paleoenvironment at the time of drifting.In this study, we conducted field surveys at Sekinehama in the northern part of the Shimokita Peninsula and found several drift pumices. Furthermore, here we report that the drift pumices are erupted from Ulleung island (U-2) and Towada volcano (To-Cu), which are correlated based on the major-element composition of pumices, and crosschecked by 14C dating of humus under the drift pumice layer.

Keywords: drift pumice, Towada-Chuseri (To-Cu) tephra, Ulleungdo, Shimokita peninsula

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Comparison of geological stratigraphy between three drilling cores and analysis of shallow geological structure in the Koriyama Basin, Northeast Japan

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1. Introduction

The Fukushima Renewable Energy Institute, AIST (FREA) has surveyed shallow subsurface geological analysis (ca. 100 m depth) in the Koriyama basin as part of researches to compile a suitability map for installation of ground source heat pump system. Ishihara et al. (2018) reported geological stratigraphy of an all-cores (GS-KR2015K-1, 251.60 m asl, 100 m depth) in the central part of the Koriyama basin and Kasahara et al. (2017) reported a tephro-stratigraphy of KR-11-1 core drilled in the northern part of the basin. In this study the authors reported geological stratigraphy of a new all-core (GS-KRC-1, 249.4 m asl, 80 m depth) in the southern part of the Koriyama basin and consider the shallow subsurface geological structure of the basin.

2. GS-KRC-1 core

Lithofacies: In the depth from surface to 29 m, silt and sandy-silt beds are dominant. Gravel layers are also intercalated at 3-8 m, 13.5-14.0 m, and 18-24 m depth. A tephra layer (volcanic glass ~ pumice sand beds) is detected from 27.0-27.4 m depth. Facies from 29 to 80 m mainly consist of gravel layer and a pyroclastic flow sediment is intercalated at 52-65 m depth.
Dating result: Two radiocarbon ages of wood fragments obtained from the core (1.78 and 2.12 m depth) show ca. 50,000 cal yBP, respectively. A FT age of pyroclastic flow sediment (55-59 m depth) shows 3.4± 0.4Ma.

3. Discusstion

Based on stratigraphic correlation between GS-KRC-1 and other two cores (GS-KR2015-1 and KR-11-1), it was interpreted that silty-dominant layers with a depth of 0-29 m is the upper Koriyama Formation and gravel layers with a depth of 29-52 m is the lower Koriyama Formation or the Shirakawa Formation, respectively. The age of the pyroclastic flow sediment is well correlated with the age of the pyroclastic flow sediment (3.2 ±1.3Ma) of GS-KR2015-1 (41.9-49.0 m depth), indicated that they are the same pyroclastic flow sediments.
The pyroclastic flow sediments of the GS-KRC-1 core is distributed at about 184.4-197.4 m asl, which its base level is 10 m lower than the pyroclastic flow sediment of the GS-KR2015-1 (202.6-209.7 m asl). It is indicated that terrace or hilly landform existed just before deposition of the pyroclastic flow sediments.

Keywords: Koriyama Basin, drilling core, subsurface geological stratigraphy, tephra

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Holocene geomorphic development of the Kinu river system constrained by the dissected river valleys formed after MIS 5.

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1.Introduction

Kinugawa Lowland located in the northern part of the Kanto Plain is a relatively stable area of structural movement and is characterized by fluvial terraces of different ages after MIS 10 at around the same altitude (Kaizuka 1957; Suzuki and· Koike, 2000).
Unlike the eastern and central parts of the Kanto Plain, there are few studies of this region and the paleo shoreline in the last interglacial period in this area has not been clarified yet (Sugai et al. 2013). In addition, the relation between the distribution of dissection valleys and landform development are hardly understood in the northern area of the plain.
Coupling geologic column data and terrain analysis using GIS in the Kinugawa Lowland, we discuss fluvial processes and river valley development associated with river course changes and eustatic sea level changes since MIS 5.

2. Method

Erosion Depth distribution Map (EDM) was made based on the difference between Summit Level Map and 10m DEM(GSI) by Arc GIS (ESRI).
Thickness of Holocene valley-fill deposits was measured based on the interpretation of borehole data.
Sinuosity of dissecting valleys and river course were measured by using GSI map.

3. Result and discussion

EDM shows that the Nisinire River valley (Valley B) is deeper than the present Kinu River valley (Valley A). In contrast the thickness of Holocene deposits in Valley A was thicker than that in Valley B. Sinuosity of Valley A and B were almost the same, which implies that both Valley A and B were originated from the paleo Kinu river channel A and B running on the present Takaragi river terrace area probably in MIS 4 as active and unstable channels on a large alluvial fan surface (proto-Takaragi surface). And then, the cannel A started incising to form deep valley accompanied with BG (basal gravel layer) corresponding to a decline in sea level in MIS 3 to 2 i.e. Valley A. Finally valley A has been filled with thick fluvial deposits because of abundant sediment supply from the upstream of the Kinu river system. On the other hand. the channel B became a misfit river to form a shallow valley and then gradually buried the valley during the Holocene because of the luck of the upstream of the Kinu river.

Keywords: Kinu River, Takaragi Terrace, Dissection Valley, Summit level map

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Depositional stratigraphy based on XRF, tephras and particle size analysis of core drilled in the central part of the Kanto plain, Sakai town, Ibaraki prefectural and Kuki city, Saitama prefecture (preliminary report)

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In the Kanto plain, a large frame of the topography has been formed by glacial sea level fluctuations and the Kanto basin movement caused by plate subduction. From the southwest part of Ibaraki prefecture to the eastern part of Saitama prefecture, it is the center of the basin movement and the sediments of the last interglacial period are buried underground. In this study, the distribution depth of marine stratification was investigated using the boring core excavated by the Tone River Upstream River Office at Sakai town in the southwestern end of Ibaraki Prefecture and Kurihashikita, Kuki city in Saitama Prefecture (S12 Core and KHN Core). Observation of layer phases and laser diffraction type particle size analysis, sulfur analysis using WD-XRF, and compositional analysis of volcanic glass of tephra using SEM-EDS were carried out. The S12 core, whose hole top elevation is 12.19m, consists of from deeper part, a silt layer containing a lot of shell fragments (unit 1a, b), a dark gray upper coarsening sand layer (unit 2), a slightly organic silt layer (unit 3), coarse sand mixed with scoria (unit 4) severely color-changing silt (unit 5) and loam layer containing a lot of volcanic ash (unit 6). With reference to the results of sulfur analysis using XRF, we can reconstruct topographical change as follows. it is conceivable that on the upper part of the silt layer (Unit 1) containing sea shells which are seafloor sediments, as the influence of rivers increased at the end of the maritime, delta sand (unit 2) accumulated, and sedimentary sand (Unit 4) accumulated at the stage of regression. In the silt layer containing the shellfish, it is thought that the value of sulfur increased with the upward fine granulation as the sea was at the stage of transgression. At the depths of 20 to 26 m and in the latter half of 29 m the value of sulfur became small, so there is a possibility that it was located in a brackish water area such as an estuary and lagoon at that time. Five layers containing no-weathering white pumice with a diameter of a few mm were observed at depths of 27.5 m - 28.5 m (under above-mentioned Unit1) of the KHN core, whose hole top elevation was 15.5m, named KHN 1 - KHN 5 from the shallow one. KHN 1 and KHN 2 were included in cross lamina, and KHN 3, KHN 4, and KHN 5 were in a single layer. As a result of the principal component analysis of the volcanic glass, KHN 1, KHN 2, KHN 3 may not be a single tephra but may have been deposited secondarily. KHN 4 and KHN 5 are in good agreement with the results of principal component analysis of Tanashita pyroclastic flow of Akagi Volcano, which is considered to be comparable to this. The Tanashita pyroclastic flow (Arai, 1962; Moriya, 1968, Takemoto, 1998) is compared with the Akagi Mizunuma 8 descent pumice (Yamamoto, 2016) and the descent period is supposed to be the first period of MIS 5e (Yamamoto, 2016). Therefore, Unit 1 is considered to be the bay mud layer of Paleo-Tokyo Bay deposited at the stage of transgression in MIS 5e.

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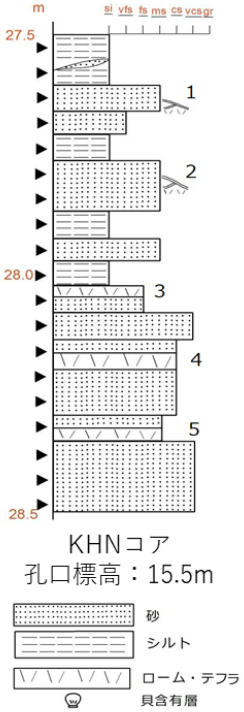
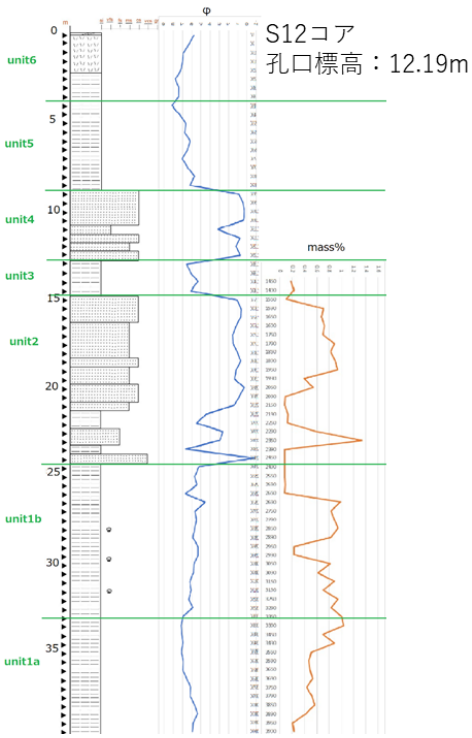
Keywords: boring core, late Pleistocene, Paleo-Tokyo bay





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Spatial distribution of Musashino Gravel in Tokyo using an automated program analyzing geological sequence from a vast number of boring data.

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Musashino Gravel is one of the supporting ground in the Musashino upland spreading in the western Tokyo, and revealing its spatial distribution is significant from an engineering point of view.
In this study, we use a new system, an ‘automated program analyzing geological sequence’ (Hori et al., 2018) from a vast number of boring data and GIS program.
Recently, according to Endo et al. (2018), division of the Musashino uplands has been revised, and subdivision of the Musashino surface has been proposed. Also, in the Funatsu et al. (2018), the inclination angle the top surface of the Musashino Gravel is suggested.
The elevation values of the upper and lower surface of Musashino Gravel, by ‘automated program’ (Hori et al., 2018) were mapped to show paleo-topography with 50m mesh.
When the upper surface of the Musashino Gravel was shown by a contour map, it was possible to clearly distinguish ridges and valleys from unevenness of contour lines. Among them, the valley topography is similar to the shape of rivers that currently flow on Musashino surface.
On the Kodaira surface (M1a) by Endo et al. (2018), the contour interval is wide and flat. The Meguro-dai surface (M1b) is gentle in the west, which is high, at the altitude of 27 m, but in other aspects the border was 30 m in altitude.
On the other hand, the bottom surface contour map of the Musashino Gravel seem that, the valley continues to the west side. But the top surface can be seen that the valley was buried by the Musashino Gravel at the west zone. Other than that there is not much difference between the topography such as valley on the top surface and bottom surface.
When comparing the obtained features with the topographic classification by Endo et al. (2018), the distribution in thickness of Musashino Gravel and the top and bottom surface contour maps are corresponded well.

Keywords: Musashino gravel layer, Musashino platform, automated program analyzing geological sequence , Borehole data

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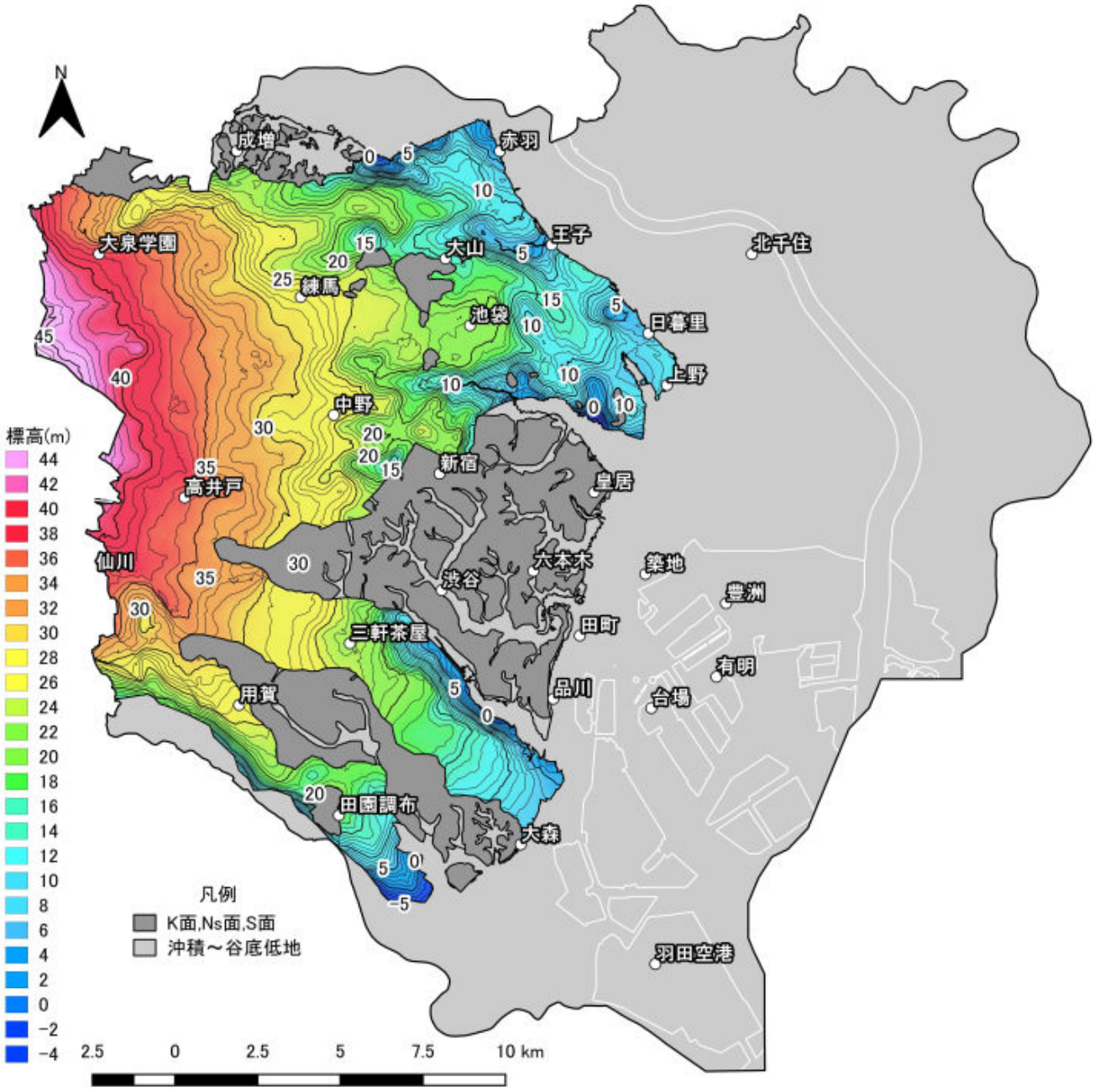

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Sedimentological features of Fuji-Sagamigawa Lahar deposits from the upper reaches of Sagami River, central Japan

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Lahar is a general term for a rapidly flowing mixture of rock debris and water (other than normal stream flow) from a volcano (Smith and Fritz, 1989). Fuji–Sagamigawa Mud Flow (Lahar) originated from the Fuji Volcano (Older Fuji) around 22 ka (Machida, 2009) distributes along the Sagami River Valley. The lahar deposits have been reported from Tsuru City, Yamanashi prefecture to Zama City, Kanagawa prefecture which apart ca. 90 km from the present Fuji Volcano summit. At least 3 events have been recognized based on field surveys by Geographical and Geological Research Group in Sagamihara City (1990). Detailed description of outcrops of the lahar deposits in the upper reaches along the Shakunagashi River, a branch of Katsura River (Sagami River) revealed that (1) the lahar deposits are divided into 6 or more units with less than 3m thick, (2) the units do not show characteristics of hyper–concentrated flow deposits, and (3) the units often intercalate parallel–cross bedded layers. These features imply that the lahar deposits in the upper reaches are formed by multiple flow events.

Keywords: lahar deposits, Fuji-Sagami River Mud Flow, Katsura River (Sagami River)

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Terrace classification and geomorphological development process around Shinano river and Uono river junction area in Niigata prefecture

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Shinano river basin has long been considered an active folding area in the Niigata prefecture. A study on the diastrophism has been research the field of geomorphology, geology and geodesy. This area river terrace spreads. It has been reported that abnormal inclination to the mountain side or the upstream side of the river due to the active fold area. In the Uchigamaki area located near the junction area of Uono river and Shinano river, relatively new river terrace formed after the AT(26-29 ka) descent period has spread. In this study, aerial photograph interpretation, field surveys, a knitting year by surrounding ruins age, and terrain analysis, for example creation of river bed longitudinal section were carried out to discuss landform evolution through chronology of river basin and crusted determination in this area.
As the result of aerial photograph interpretation, field surveys, and reference data of preceding studies, river terraces in this area was divided into 11 terraces consisting of L1 to L11 terrace in total. The Araya ruin (1.725 ka) is located on the L3 terrace. The Saigura ruin (1ka) is located on the L7 terrace. The cross section along river of terrace was created using 1m grid DEM by Lidar data. Creating a river bed longitudinal section of the Uchigamaki area showed a northeast inclination in all aspects. Focusing on the inclination degree of each surface, the L1 surface to the L5 surface are steeper than the current riverbed. and the L6 and subsequent surfaces showed a gentle slope.
Generally, higher terrace ratio to riverbed is older. The Shinano river side could divide into many terraces but Uono river side couldn`t it. The riverbed longitudinal section in Uchigamaki area showed a northeastward tilt in all terraces. That`s why, these river terraces formed by Shinano river.
In addition, there is a decline in the sea level as a factor of formation of the river terrace. Kaizuka (1977) suggest, in the middle watershed, the river terrace formed in the glacial period is steeply inclined and is buried in the gradual inclined it formed in the post glacial period. Purpose based on this area, before the L5 terrace, it was formed during the glacial period because of the steep slope, but it is suggested that it could be buried in the L6 terrace formed in the post glacial period.
As the results of consideration flow path change of the Shinano river is as flows. Originally flowed southeastward around the Uchigamaki shrine from the northeast direction and had joined the Uono river at Aikawaguchi. The river changed the flow from the west to the east as it took off at L1, L2 terrace. The river began meandering from the time the L3 terrace was separated until 1.725 ka. After L6 terrace separated the river turned from the southwest to the northeast direction which is close to the current flow path It is thought that the water flowed out after the L7 terrace until 1ka and became the current flow path.

Keywords: Shinano River, Uchigamaki, Terrace division, Vertical section of riverbed

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Estimation of the Source of Sand Beach Sediment in Tsuruga Bay, Fukui Prefecture: Focusing on Grain Size Analysis and Composition of Clastics

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In order to clarify the dynamics of the beach sand in the sandy coast of Tsuruga Bay, we carried out grain size analysis, composition of clastics and color analysis of beach and river bed sediments. The west coast of Tsuruga Bay consists mainly of granitic rocks and the east coast mainly of accretionary complex. As the result we revealed that the transportation and sedimentation process along Tsuruga Bay coasts might not be closed within each coast and its inflowing rivers, but it may be influenced by the coastal current.

Keywords: sand beach sediment, grain size analysis, composition of clastics

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Characteristics of Latest Pleistocene to Holocene deposits of two cores obtained from the inner part of the Nobi Plain, central Japan

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The Nobi Plain, central Japan, is a Holocene fluvial–coastal plain formed mainly by the Kiso, Nagara, and Ibi rivers. This poster shows sedimentary characteristics of cores KG and OZ obtained from the inner part of the plain. Two cores were taken from the present floodplain of the plain where prodelta deposits are not distributed. The borehole sediments were divided into depositional units based on lithology, water content, color, mud content, radiocarbon age, and fossil diatom. KG1 and OZ1 are channel deposits composed mainly of sand and gravel. KG2 and OZ2 consist of silt to medium sand estimated to have accumulated under intertidal/subtidal environment near the river mouth, and overlay KG1 and OZ1, respectively. KG3, characterized by organic-rich mud, covering KG2 is interpreted as floodbasin deposits. OZ3, overlies OZ2, consists of coarse sand to very fine sand, and the upper part shows a fining-upward succession. This unit may have been formed under in-channel and point bar environment.

Keywords: sedimentary environment, radiocarbon age, floodplain, Holocene, Nobi Plain

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Subsurface distribution of marine deposits during the MIS 5e and vertical displacement inferred from microfossil evidences and borehole logs in northern Ise Plain, central Japan

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This study identified Marine Isotope Stage [MIS] 5e marine deposits inferred from borehole logs, diatom and pollen fossil analyses and radiocarbon ages for estimation of vertical displacement in the northern Ise Plain, western coast of the Ise Bay. Late Pleistocene marine and riverine terraces are distributed widely in the northern Ise Plain (Ishimura, 2013). In the northern Ise Plain, active faults, including the Yoro-Yokkaichi Fault Zone and Eastern margin Fault Zone of Nunobiki Mountains, are distributed at the boundary between Pleistocene terraces and alluvial lowland. Although the study area, southern part of Suzuka City, is located at the boundary of both fault zones, activity and tectonic relationship of them are unclear. Therefore, we performed geomorphological classification by interpretation of aerial photos, analyses of borehole logs, diatom and pollen fossils to identify MIS5e marine deposits.

Late Pleistocene terraces, middle and lower, are distributed in the study area, which was deformed in their eastern margins by active faults. The top of middle terraces has 5 to 15 m T.P. and corresponding to older middle terrace (tm1) of Yoshida (1987) and Kambe terrace (tmk) of Yoshida (1984). The eastern margin of middle terrace around the Ozaga-ike pond shows flexure structure, indicating that active faults are distributed at the boundary between the middle terrace and alluvial lowland.

Late Pleistocene deposits were able to be divided into three units, Unit A to C in ascending order, and the Unit B subdivided into four subunits (B-1 to 4). Unit A is composed of solid sandy and muddy deposits with freshwater diatom species, which suggesting that this unit is a part of Pliocene Tokai Formation. Unit B is composed of alternated layers of muddy and sandy sediments; Subunit B-1: marine muddy sediment, Subunit B-2: sandy sediments, Subunit B-3: freshwater muddy sediments with abundant freshwater diatom species and plant materials showing radiocarbon ages of 50,440±760 yrBP and >53,940 yrBP, Subunit B-4: gravelly sediments, corresponding to surface gravelly deposits of the middle terraces. Unit C is alluvium deposits, soft and humic muddy deposits. The subunit B-1 has abundant brackish to marine water diatom species and Lagerstroemia pollen, suggesting that this unit deposits during the MIS 5e.

The distribution pattern of MIS 5e marine deposits, subunit B-1, is possible to indicate vertical displacement since the MIS 5e, ~120ka. Elevation of the top of the subunit B-1 is ~-13.5 to −15.5 m T.P. in western side of the presumed fault, and ~-17. 5 m T.P. in eastern side. Therefore, vertical displacement is estimated to be more than 2 m, and vertical slip rates since the MIS 5e are suggested to be 0.02 m/kyr. In addition, the bottom of the subunit B-3 suggest that vertical displacement is more than 6.5 m, and vertical slip rate is more than 0.05 m/kyr. There estimated values is similar to the slip rate of the Chisato Fault, northern margin of Eastern margin Fault Zone of Nunobiki Mountains, 0.05 to 0.21 m/kyr (Mizutani, 2017).

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Keywords: MIS5e, diatom fossil assemblage, pollen fossil, Yoro-Yokkaichi Fault Zone, Eastern margin Fault Zone of Nunobiki Mountains, subsrface geology

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Detection of the Amagi-Kawagori tephra (Kg) in the Shijima lowland, the Shima Peninsula, and its significance to reconstruct tsunami history

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The coast from the eastern to the southern part of the Kii Peninsula facing the Nankai Trough is located near the boundary between the Tonankai and the Nankai Segment of the past large earthquakes. Therefore, reconstruct of the tsunami history in this area is very important for evaluating the rupture area of the past Nankai Trough Earthquake. Tsunami deposit surveys have been carried out in marshes and lagoons along the coast, but it is difficult to correlate between each survey site. Here we report that the Kg tephra (around 3100 cal yBP), which is effective wide-spread tephra as a key to the correlation of the tsunami events, was found in marsh deposit obtained from the excavation survey at the Shijima Lowland, the Shima Peninsula.

In the Shijima Lowland, Fujino et al. (2018) identified ten sand layers (Sand A - J) recording tsunami history in marsh deposit. In this study, we carried out excavation survey using hand corer to a depth of 483 cm at the lowland, and detailed microscopic observation to each 5 cm thick samples from the obtained core. As a result, pumice type volcanic glass was detected from the depths of 265-270 cm and 275-280 cm. Particularly in the vicinity of 276 cm in depth, about 5 mm thick of pale white layer can be observed visibly. Also, from the A2 core in Fujino et al. (2018), about 5-8 mm thick of pale white layer in the organic silt between Sand G and Sand H was identified, and the same type of volcanic glass was detected.

Measuring the refractive index of these volcanic glasses using MAIOT, the counted value was concentrated in the range of 1.499 to 1.501, which is well-matched to the value of the Kg tephra (1.495-1.502) proposed by Machida and Arai (2003). Component analysis data by EDX performed by Furusawa Geology Ltd. is also consistent with previous research results on the Kg tephra.

The detected horizon of the Kg tephra in the A2 core constrains the age of Sand G and Sand H. As a result of this study, it can be estimated that those are 3100-2740 cal yBP and 3600 - 3100 cal yBP respectively.

In the southernmost part of the Kii Peninsula, Kitagawa et al. (2017) reported the Kg tephra detected from coastal marsh deposit intercalated between event sand layers whose ages were estimated to be 2950-2470 cal yBP and 3390-3100 cal y BP respectively (Shishikura et al., 2014). These sand layers can probably be correlated between two sites. The Kg tephra is an important key to reconstruct the tsunami history along the coast of the Kii Peninsula, and it is expected to clarify the occurrence pattern of the Nankai Trough Earthquake.

Keywords: Shima Peninsula, Shijima Lowland, Nankai Trough, Amagi-Kawagodaira tephra, tsunami history, tsunami deposit

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Holocene paleoenvironmental changes based on biomarker analysis at the western part of the Kawachi plain, Osaka, Japan

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1. Introduction

To reconstruct past environmental variation in the Quaternary strata of the Osaka plain, analysis of microfossil assemblages such as foraminifera and ostracods have been conducted by previous studies (e.g., Umeda et al, JPGU2018). Although these microfossil assemblages provide estimates on the hydrospheric environments, their occurrence is mainly limited to marine deposits. In this study, the organic biomarker molecules derived from terrestrial and aquatic organisms have been investigated in the Holocene sediments of Sakuranomiya East drill core to reconstruct the past variations in the source of organic matter (OM) and depositional environments at the western part of the Kawachi plain.

2. Analytical methods

Biomarker analysis was performed on the 20 sediment samples of an 18 m long Sakuranomiya East core, which have been drilled at Sakuranomiya East park (altitude + 0.5 m), Miyakojima, Osaka City. The Sakuranomiya East core is consist of the Holocene Nanba Formation and divided into 4 units; the lower unit (SH-1; altitude -19.50 to -17.60 m) consists of medium sand to mud layers, SH-2 (altitude -19.50 to -17.60 m) consists of medium sand to fine sand layer, SH-3 consist of mud layer (SH-3: altitude -16.00 to -8.90 m), and SH-4 (altitude -8.90 to -1.60 m) consists of mud to fine sand layers. Biomarker analysis was performed at 20 horizons spanning SH-1 to SH-4 including mud and sand layers. Lipids were ultrasonically extracted from sediments with dichloromethane and methanol, and subsequently divided into 3 fractions (hydrocarbons, ethers/esters/ketones, and polar lipids), then analyzed by GC and GC-MS. Polar fractionation was derivatized prior to analysis. Compounds were identified based on mass spectra and relative retention time and quantified with GC-FID.

3. Results and discussion

n-Alkyl lipids (*n*-alkanes, *n*-alcohols, *n*-fatty acids) and terrestrial plant biomarkers such as friedelin and sawamilletin were identified as major compounds. The predominance of long-chain ($>C_{22}$) *n*-alkanes and *n*-alcohols with a significant amount of terrestrial plant biomarkers indicated the overall predominance of terrestrial OM throughout the studied core. This is reasonable considering that the core site is located in the incised valley of the paleo-Yamato River (Mitamura and Hashimoto, 2004). Meanwhile, the amount and chain-length distributions of biomarkers also reconstructed variations in the contribution of fluvially transported terrestrial OM. The decreasing long-chain components of *n*-alcohols from SH-1 to SH-2 were considered to coincided with sea-level rise; rapid expansion of inner bay over the Kawachi plain increased a distance from the retreating estuary which supplied terrestrial OM. The high relative concentration of sawamilletin observed in SH-2 might reflect the input from coastal Graminae vegetation at 8ka. The gradual increase of long-chain *n*-alcohols in the upper SH-3 to SH-4 initiates around the highest sea level period of ca. 6.4 ka indicating the increasing fluvial input of terrestrial OM with the progradation of river delta. In addition, an increased *n*-alkane Paq index observed in SH-4 suggests the higher input of aquatic macrophytes at ca. 4ka. In the upper part of SH-3, a higher contribution of short-chain *n*-fatty acid ($< C_{21}$) were observed. Short-chain *n*-fatty acids are considered mainly derived from aquatic organisms including planktons and bacteria. Oshiro (2018MS) estimated the bottom environment of these horizons as closed inner bay and reported the occurrence of *Buccella frigida*, detritivore foraminifera frequently occur in OM

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rich bottom sediments. Therefore, the upper part of SH-3 is characterized by the enhanced marine production along with increasing terrestrial OM input, probably deposited under the influence of estuary circulation.

Keywords: Biomarker, Osaka plain, paleoenvironmental changes

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Environmental change before and after Kikai-Akahoya tephra descent in the Miyazaki plain, Southern Kyushu

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In the early Jomon period (ca. 7.3 ka), a large Koya pyroclastic flow reached the southeastern Kyushu was reached by the eruption that occurred at the Kikai caldera about 40 km off the southern edge of the Osumi Peninsula. At this time the fine grain ash which blew up in the sky is called K-Ah tephra and it is known that it has reached the Tohoku region. Kawahata has reviewed the research on the age of the K-Ah tephra so far, also studied the positioning of the tephra in the elders of the archeology, and have considered how the K-Ah eruption had an impact on human beings and other ecosystems (Kuwahata, 2013). In this report, since the boring survey was conducted on the alluvial deposit of the Miyazaki plain where the K-Ah tephra was thickly deposited, we will report the outline of our study.
In the Miyazaki plain, the K - Ah tephra of the first deposit is 20 to 30 cm thick and is observed as a mild to fine grainy glassy falling volcanic ash. On the other hand, secondary sediments found in alluvium deposits are thickened to about 2 m in thickness due to the influence of water flow, and are composed of gray medium grain glassy volcanic ash which has been culled out. The cause of thickening of the secondary sediments of K - Ah tephra was caused by debris flow or flood flow accompanying the collapse of mountainous and hilly slopes where land - based vegetation died due to ash falling and lost water storage function Nagaoka et al. (1991) had estimated that there was. In recent years, the hypothesis that the sand layer of the K-Ah base is a tsunami event deposit immediately after the tephra ash fall has also been shown by Matsuda et al. (2016).
In July 2017, we carried out an all-core bowling in the Ikumenomori Sports park of Miyazaki City. As a result, it was possible to collect cores up to the excavation length of 15.55 m from the surface. We are conducting various analyzes such as tephra analysis, radioactive carbon dating, pollen analysis, diatom analysis, seed analysis, plant silicate analysis, shellfish analysis, foraminiferal analysis, etc., using the collected cores.
Core stratigraphy is divided into five layers A to E. Dark gray organic soil (A layer) directly beneath the embankment, gray silt layer of peaty (B layer), water deposit of K-Ah (C layer), secondary sediments and events of K-Ah tephra Sand layer (D layer), gray silt layer containing shell pieces (E layer). As a result of various natural scientific analyzes of the core, it became obvious that the K-Ah tephras secondary sediments are almost composed of bubble type volcanic glasses, and the base event sand layer includes not only K - Ah but also Aira It was also found to contain volcanic glass originating from Aira-Tn (AT) tephra. Therefore, the estuary environment has been occurred in the Miyazaki plain caused by the Jomon transgression, and it has been buried rapidly due to the secondary deposition of K-Ah, and changed to landenvironment drastically.

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Keywords: Kikai-Akahoya eruption, Miyazaki plain, Environmental change, Souhern Kyushu

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The history of volcanic eruption based on tephrochronology at Plio-Pleistocene in Japan :2 Chronology of pyroclastic flow deposits in southern Kyushu

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The frequency and the scale of the large volcanic eruption in the Japanese Islands are one of the important problems in the forecast of the long-term geosphere stability. The restoration of the history of the large volcanic eruption in the late Pleistocene has been examined by the correlation with the pyroclastic flow deposit and the distal fine ash (For example, the Ito pyroclastic flow deposit and the comparison with the AT volcanic ash of 30ka : Machida and Arai, 1974, etc). However, an older age, a lot of source volcano cannot be specified and the evaluation at the scale and age of a volcanic eruption are difficult.

In tephrochronology, identification and the comparison of the tephra based on the chemical composition analysis of mayor and trace elements of the volcanic glass from the 1990's (Yoshikawa, 1990). As a result, the comparison accuracy of an older pyroclastic flow deposit and the tephra in the remote place improves. It has come to obtain information on the large volcanic eruption the widespread tephra correlation at 5 Ma-1Ma in central Japan (Mizuno, 2000; Tamura and Yamazaki, 2004 and Satoguchi and Nagahashi, 2012). Mizuno (2001) showed that the source volcano area of the widespread tephra was definable to Chubu Sangaku, Kyushu, and Tohoku region from the element characteristic of a trace element of volcanic glass of the pyroclastic flow deposit to some degree. Tamura and Yamazaki (2015) reported on a petrology feature, the eruption scale, the source and the age of the tephra about 36 widespread tephra layers of 5Ma-1Ma. The Tohoku origin tephra layers are concentrated on 2Ma-1Ma and the Chubu Sangaku origin tephra concentrates on 3Ma-1.5Ma. The other side, in Kyushu and Hokkaido, there are a lot of Pliocene-early Pleistocene pyroclastic flow deposits to which the comparison with the distal tephras is not done. For the construction of the volcanic eruption, we are to advance the tephra research on Hokkaido and Tohoku where information is especially little. This study has correlated with pyroclastic flow deposits distributed in southern Kyushu and widespread tephras Pliocene and early Pleistocene.

In the late Pleistocene, the volcanic eruption was gushed in southern Kyushu and, a large amount of pyroclastic flow was gushed. As a result, the old age pyroclastic deposits are hidden under a cover, and it is difficult of tephrochronology of the pyroclastic flow deposit at early Pleistocene and Pliocene of southern Kyushu (Miyaji and 1987). Mizuno et al.(2017) examined the comparison with widespread thephras that the feature of the Kyusyu origin and pyroclastic flow deposits in southern Kyusyu. The Sendai pyroclastic flow deposit (Snd: Ohta, 1971) correlated with Habutaki1-MT2 tephra (Hbt: 2.9Ma: Tomita and Kurokawa, 1999; Tamura et al., 2016) and the Akune1 pyroclastic flow deposit (Akn1: 3.3Ma: Miyaji, 1987) correlated with Tsuchimaru2 tephra (Yoshikawa, 1975), Biroku1 tephra (Yoshikawa, 1988), TenjinikeL2 tephra (Yoshikawa and Ozaki, 1986) . In southern Kyusyu, the volcanic eruption was active in about 3Ma. This research investigated, described the pyroclastic flow deposits of the Koriyama Formation at Yaeyama area, Kagoshima Prefecture and tried to correlate with two pyroclastic flow deposits and the widespread tephras at Plio-Pleistocene.

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The Miyawaki pyroclastic flow deposits (Myk: Uchimura et al., 2007) is thickness of about 5m and white fine grain, unremarkable pumice in the type locality. Myk is containes hornblende, orthopyroxene and a small amount of biotite and clinopyroxene. The K-Ar age of Myk is 2.88±0.16Ma, 2.71±0.16Ma (Uchimura et al., 2007). The new tephra found in Yamanouti village, Sendai City is called Ymn is thickness of about 10cm and white fine grain. Ymn mainly consists of glass shard bubble-wall type with hornblende and orthopyroxene as phenocrysts. The chemical composition of the glass phase in these tephras, Myk is characterized as poor in CaO (0.9%) and rich in K_2O (4.3%) and Ymn is characterized as rich in CaO (1.6%) and poor in K_2O (3.4%).

There are Sunasaka tephra (Sns: Yokoyama et al., 1979) of the Kobiwako Group and Mori tephra (Wada, 1978) of the Tokai Group as a similar tephra to the age and the chemical composition of the glass phase of Myk. However, biotite is not contained in Sns and Mori. The problem remains in the correlation. As for Asashiro-Tomoda2 tephra (Ass: 2.6Ma: Tamura et al., 2008), a chemical composition of the glass phase and mineral composition is similar to Ymn. Ass exists in the upper Hbt1 in central Japan such as Osaka, Kobiwako and Hokuriku Groups. The possibility that Ymn is compared with Ass is high. A further investigation will be hoped for in the future.

Keywords: Widespread tephra, Plio-Pleistocene, History of volcanic eruption, Southern Kyusyu, Pyroclastic flow deposit, Chronology

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Identification of Ks5 tephra and similar tephras based on trace element composition of volcanic glass shards

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Some vitric ash tephras of the middle Pleistocene are similar in major element composition of glass shards and difficult to discriminate. In this study, we examined indices to distinguish them using the trace element composition of volcanic glass shards.

Nanayama and Nakazato(2018) focused the BT72 tephra which horizon was above MIS11 and the Ks5 tephra which horizon was under MIS11. Then they correlated these tephras and pyroclastic flow sediments in southern Kyushu. As a result, they found differences in the trace element composition of glasses of BT72, Wakimoto and Ks5, and showed that tephras similar to Ks5 were intercalated in three horizons.

In this study, we added the analysis of K1-175 and K1-223 tephras of the Higashinada core (Yoshikawa et al., 2000) which were the Ks5-like tephra, and the significance (5% level) of the difference in analysis mean values of trace components was analyzed by Tukey-Kramer test (Maruyama et al., 2017) and reconsidered the correlation of these tephras. LA-ICP-MS of volcanic glass shards was quantitated for 34 elements from Sc to U by the procedure of Furusawa et al. (2018) and investigated 32 elements except Cr and Ni with large variations. The ratio of the number of elements with no significant difference between BT72 and Wakimoto for Ks5 is 53%. And that of Wakimoto about BT 72 is 56%. Such an examination is considered to be an identification index of these tephras. On the other hand, the combinations of which the ratio of the number of elements with no significant difference is 75% or more are Hegawa pfd, Ogoyama tephra, and K1-223 for Ks5, Oda pfd for Wakimoto, K1-175 for BT72. These tephras are considered to show high similarity.

Since K1-223 is intercalated to low sea level horizon between marine clays of the Osaka Group, correlation with Wakimoto is predicted, but here it is correlated with Ks5. It is necessary to accumulate these analysis data in the future and to study the source pyroclastic flow deposit of BT72.
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Keywords: LA-ICP-MS, U-Pb age, tephra

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Climate, vegetation and fire history of the last ~100 ka from archaeological sites of Belan valley, north-central India

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Late-Paleolithic to Neolithic archaeological sites situated in north-central India is known for its well-preserved artifacts and the first evidence of domesticated rice (*Oryza sativa*) from the Indian subcontinent. Therefore, these archaeological sites provide an ideal platform to understand the linkage of hominins with climate, vegetation and fire events during the late Quaternary period. As the fire disturbance in the modern ecosystem appears to be one of the important processes in shaping vegetation and landscape dynamics, its identification in paleo-records would enhance our understanding of the past environment. However, climate, as well as human, can equally induce the fire at the stand. Therefore, unraveling the natural and hominin induced factor is equally important to comprehend the paleoclimatic and paleovegetation conditions at a regional and global scale.

In this study, 49 paleosols sampled from six archaeological sites of Belan River. Paleosols were analyzed for *n*-alkane distribution, $dD_{n\text{-}alkane}$, $d^{13}C_{n\text{-}alkane}$ value and Charcoal count to reconstruct the climate, vegetation and fire events. *n*-Alkane distribution pattern, carbon preference index ($CPI_{25\text{-}33}$) and average chain length ($ACL_{15\text{-}33}$) used to delineate the source of organic matter (OM) in the paleosols which suggest a dominant contribution from terrestrial plants. Three samples of lower $CPI_{25\text{-}33}$ (~1.0) and $ACL_{15\text{-}33}$ (~23.0) observed that indicate enhanced degradation of OM. The lower $CPI_{25\text{-}33}$ sample showed a prevalence of mid to short-chain even-numbered carbon (maximum at *n*-C_{16} or n-C_{18}) which was also observed in the previous study from the archaeological site for fire events (Eckmeier et al., 2009). Additionally, macro-charcoal analyses (n=40) showed degraded paleosols exhibits higher charcoal which endorses its exposure to fire. The macro-charcoal analysis suggests paleofire events in the Belan valley at i) ~58ka BP, ii) ~26ka BP and iii) ~8ka BP. $dD_{n\text{-}alkane}$ values suggested lower rainfall condition during Large Glacial Maximum (LGM; ~20-25ka BP) and during the early-Holocene (~11ka BP). The intensification in rainfall observed at i) ~60ka BP, ii) ~26ka BP and iii) ~10-3ka BP which corresponds to observed fire events. The $d^{13}C_{n\text{-}alkane}$ values showed the dominance of grassland between ~30-25ka BP with the cool and dry environment due to LGM which was favorable for wildfires. Further, the fire event at ~26ka BP identified at Main Belan temporarily overlaps with Mahagara and Koldihwa archaeological site. The absence of any major sign of thermal alteration of paleosols (supported by *n*-alkanes) in Koldihwa and Mahagara with indicates the local nature of the paleofire events. Similarly, fire events observed in this study coincides with the high rainfall condition which is unconducive to natural wildfires. Further, fire disturbance increases in the early Holocene to mid-Holocene overlaps with the timing of domestication of agriculture in the Belan valley. Therefore, this study postulate that the paleofire events were mostly induced by hominin groups living in the Belan valley.

E. Eckmeier., GLB.Wiesenberg., 2009. Short-chain *n*-alkanes (C_{16}-C_{20}) in ancient soil are useful molecular markers for prehistoric biomass burning. Journal of Archaeological Science, 36, 7, 1590-1596.

Keywords: Archaeology, Stable Isotope, n-Alkane, Late Quaternary, Charcoal

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[J] Poster | H (Human Geosciences)：H-QR Quaternary research

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_16

[H-QR05] Quaternary, Diachronic dynamics of human-environment interactions

convener:Mamoru Koarai(Earth Science course, College of Science, Ibaraki University), Ken Ikehara(Institute of Geology and Geoinformation, National Institute of Advanced Industrial Science and Technology), Masayuki Hyodo(Research Center for Inland Seas, Kobe University)

Humans have attained their specific development by indigenous cultures and evolved through environmental adaptation. The session raises issues of human-environmental interactions, views from diverse changes of climate, ocean, land and biota having made striking influence on humans. It welcomes various fields from human-environment change and their chronometric dating among Quaternary disciplines.

[HQR05-P01] Local marine reservoir age variability at Luzon Strait and Ryukyu Islands during the Holocene

*Shoko Hirabayashi[1,2,3], Yusuke Yokoyama[2,3], Atsushi Suzuki[4], Tezer Esat[5], Yosuke Miyairi[2], Takahiro AZE[2], Fernando Siringan[6], Yasuo Maeda[7], Hironobu Kan[1] (1.Graduate School of Social and Cultural Studies, Kyushu University, 2.Atmosphere and Ocean Research Institute The University of Tokyo, 3.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 4.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 5.Research School of Physics and Engineering, The Australian National University , 6.Marine Science Institute, University of the Philippines, 7.Institute of Natural and Environmental Sciences, University of Hyogo)

[HQR05-P02] Holocene sea-level and paleoenvironmental reconstruction using radiocarbon local marine reservoir age and geophysical modeling in Tongatapu, Kingdom of Tonga

*Naoto Fukuyo[1,2], Anthony Purcell[3], Geoffrey Clark[4], Phillip Parton[4], Yusuke Yokoyama[1,2], Yosuke Miyairi[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Department of Earth and Planetary Sciences, Faculty of Science, University of Tokyo, 3.Research School of Earth Sciences, The Australian National University, 4.College of Asia and the Pacific, Australian National University)

[HQR05-P03] The environmental change from lagoon sediment along Nakai Trough in Japan during the past 2000 years.

*Cho Ara[1], Kaoru Kashima[1], Jonathan D Woodruff[3], Koji Seto[2], Kazuyoshi Yamada[4], Kota Katsuki[2], Takumi Sato[2], Caroline Ladlow[3] (1.Kyushu University, 2.Shimane University, 3.University of Massachusetts, 4.Museum of Natural and Environmental History)

[HQR05-P04] Discovery and these sources of drift pumices interbedded in coastal sediments at Sekinehama, in the northern part of Shimokita peninsula, Aomori prefecture

*Reona Hiramine[1], Kaori Aoki[2], Daisuke Ishimura[1,2], Makoto Kobayashi[2] (1.Department of Geography, Tokyo Metropolitan University, 2.Research Center for Volcanic Hazards and Their Mitigation, Tokyo Metropolitan University)

[HQR05-P05] Comparison of geological stratigraphy between three drilling cores and analysis of shallow geological structure in the Koriyama Basin, Northeast Japan

*Takeshi ISHIHARA[1], Takehiko Suzuki[2] (1.Advanced Industrial Science and Technology, 2.Tokyo Metropolitan University)

[HQR05-P06] Holocene geomorphic development of the Kinu river system constrained by the dissected river valleys formed after MIS 5.

*Taiga Kimori[1], Toshihiko Sugai[2] (1.The University of Tokyo,Graduate School of Frontier Sciences,Dept. of Natural Environmental Studies, 2.The University of Tokyo)

[HQR05-P07] Depositional stratigraphy based on XRF, tephras and particle size analysis of core drilled in the central part of the Kanto plain, Sakai town, Ibaraki prefectural and Kuki city, Saitama prefecture (preliminary report)

*Tatsuki Miyamoto[1], Toshihiko Sugai[2], Kunihiko Endo[3], Natsuki Sasaki[2], Marie Noguchi[4], Sayuri Mitsuhashi[5] (1.Department of Earth and Planetary Environmental Science, The University of Tokyo, 2.Department of Natural Environmental Studies, Institute of Environmental Studies, Graduate School of Frontier Science, The University of Tokyo, 3.Nihon University, 4.Paleo Labo co.,ltd., 5.the Tone River Upstream River Office)

[HQR05-P08] Spatial distribution of Musashino Gravel in Tokyo using an automated program analyzing geological sequence from a vast number of boring data.

*Suginaka Yusuke[1], Kunihiko Endo[2], Shigeko Ishiwata, Toshihiko Sugai[3], Tatsuro Chiba[4], Taro Funatsu[3], Toshio Nakayama[5], Shinzaburo Hori[1] (1.Research Center of Computational Mechanics, Inc., 2.Nihon University, 3.Department of Natural Environmental Studies, Institute of Environmental Studies, Graduate School of Frontier Science, The University of Tokyo, 4.Asia air survay , 5.Tokyo metropolitan)

[HQR05-P09] Sedimentological features of Fuji-Sagamigawa Lahar deposits from the upper reaches of Sagami River, central Japan

*Masaaki Shirai[1], Mika Takehara[2], Takako UTSUGAWA[3] (1.Tokyo Metropolitan University, 2.Hachioji-City Office, 3.Rissho University)

[HQR05-P10] Terrace classification and geomorphological development process around Shinano river and Uono river junction area in Niigata prefecture

*Koseki Toshifumi[1], Mamoru Koarai[1] (1.Department of Earth Sciences, College of Science, Ibaraki University)

[HQR05-P11] Estimation of the Source of Sand Beach Sediment in Tsuruga Bay, Fukui Prefecture: Focusing on Grain Size Analysis and Composition of Clastics

*Akiko MATSUMOTO[1], Kiyokazu KAWAJIRI[2], Sumiko KUBO[1] (1.School of Education, Waseda Univ., 2.Sagamihara City Museun)

[HQR05-P12] Characteristics of Latest Pleistocene to Holocene deposits of two cores obtained from the inner part of the Nobi Plain, central Japan

*Kodai Hasada[1] (1.Faculty of Letters, Hosei University)

[HQR05-P13] Subsurface distribution of marine deposits during the MIS 5e and vertical displacement inferred from microfossil evidences and borehole logs in northern Ise Plain, central Japan

*Yoshiki Sato[1] (1.Advanced Industrial Science and Technology, Geological Survey of Japan)

[HQR05-P14] Detection of the Amagi-Kawagori tephra (Kg) in the Shijima lowland, the Shima Peninsula, and its significance to reconstruct tsunami history

Saki Yoshida[1], *Masanobu Shishikura[2], Hideaki Maemoku[1], Shigehiro Fujino[3] (1.Hosei University, 2.Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology, 3.University of Tsukuba)

[HQR05-P15] Holocene paleoenvironmental changes based on biomarker analysis at the western part of the Kawachi plain, Osaka, Japan

*Yukiko Ishino[1], Hideto Nakamura[1], Muneki Mitamura[1] (1.Osaka City University)

[HQR05-P16] Environmental change before and after Kikai-Akahoya tephra descent in the Miyazaki plain, Southern Kyushu

★Invited Papers

Mitsuhiro Kuwahata[2,7], Tatsuro Adachi[2], Yoshinori Tajiri[2], *Futoshi Nanayama[1,8], Shinji Sugiyama[6], Nakanishi Toshimichi[3], Ken'ichi Ohkushi[5], Tatsuhiko Yamaguchi[4] (1.Geological Survey of Japan, AIST, 2.Kyushu Univ., 3.Kyoto Univ., 4.Kochi Univ., 5.Kobe Univ., 6.Paleoenvironment Research Center Co. Ltd., 7.School board of Miyakonojyo City, 8.CWMD, Kumamoto University)

[HQR05-P17] The history of volcanic eruption based on tephrochronology at Plio-Pleistocene in Japan :2 Chronology of pyroclastic flow deposits in southern Kyushu

*Itoko Tamura[1], Kiyohide Mizuno[2] (1.Department of Geography,Graduate School of Urban Environmental Science,Tokyo Metropolitan University, 2.Research Institute of Geology and Geoinformation, Geological Survey of Japan, AIST)

[HQR05-P18] Identification of Ks5 tephra and similar tephras based on trace element composition of volcanic glass shards

*Hiroomi Nakazato[1], Futoshi Nanayama[2], Hisatoshi Ito[3], Shimpei Uesawa[3], Akira Furusawa[4], Kiyohide Mizuno[2] (1.National Agriculture and Food Research Organization, 2.National Institute of Advanced Industrial Science and Technology, 3.Central Research Institute of Electric Power Industry, 4.FURUSAWA Geological Survey)

[HQR05-P19] **Climate, vegetation and fire history of the last ~100 ka from archaeological sites of Belan valley, north-central India**

*Deepak Kumar Jha[1], Rahul Samrat[1], Prasanta Sanyal[1] (1.Department of Earth Scienes, Indian Institute of Science Education and Research Kolkata, Mohanpur -741246, India)

Local marine reservoir age variability at Luzon Strait and Ryukyu Islands during the Holocene

*Shoko Hirabayashi[1,2,3], Yusuke Yokoyama[2,3], Atsushi Suzuki[4], Tezer Esat[5], Yosuke Miyairi[2], Takahiro AZE[2], Fernando Siringan[6], Yasuo Maeda[7], Hironobu Kan[1]

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The local marine reservoir age (ΔR) varies not only spatially, but also temporally because of changes in ocean circulation associated with climatic changes. Holocene ΔR values have mainly been reported from the South Pacific, while only a few spatio-temporal reconstructions of ΔR have been published in the western Pacific. Present day, short term variations in ΔR at the Ryukyu Islands, South Japan, were previously associated with variability in the El Nino-Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). Further studies will better delineate this connection and establish the magnitude of the variability in ΔR in the western Pacific.

In this study, we measured high-resolution radiocarbon(^{14}C) ages and U/Th dates obtained from fossil corals on Luzon Island in the South China Sea (SCS) and Kikai and Kodakara Islands in Ryukyu Island Chain during the Holocene. A large ΔR variability of ~400 years was recorded at both Luzon Island and the Ryukyu Islands for the last 6000 years. An abrupt ΔR shift occurred between 5.5 ka BP and 4.0 ka BP in the northwest Pacific. Compared with the previously reported data from the Tropical East Pacific and Great Barrier reef, the timing of the shift was different because the ^{14}C content of the northwestern Pacific was affected by not only the intensity of upwelling at the Peru-Chile coast, but also by the East Asian monsoon.

This variability influences the calibration of local marine reservoir effect significantly when calibrating ^{14}C ages to calendar ages. High-resolution ^{14}C dating of marine samples became possible over the years, raising the need and importance of ΔR values to be reconsidered in high-resolution for different time periods.

Reference:

Hirabayashi et al. (2019) Local marine reservoir age variability at Luzon Strait in the South China Sea during the Holocene, *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms*, in press.

Keywords: U/Th dating, Radiocarbon dating, Local marine reservoir age, Corals

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Holocene sea-level and paleoenvironmental reconstruction using radiocarbon local marine reservoir age and geophysical modeling in Tongatapu, Kingdom of Tonga

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Reconstructing the history of Holocene relative sea levels around Tonga is important for understanding geomorphological theories and also interpreting paleoenvironmental and archaeological studies in that area. However, neither continuous sea level reconstructions nor quantitative paleoenvironmental studies using geochemical/physical methods are available. In this study, we reconstructed Holocene sea level changes in Tongatapu island using radiocarbon local marine reservoir age (ΔR) and glacio-hydro adjustment (GIA) modeling. Furthermore, we interpreted the relationship between the reduction of the size of bivalves (*Gafrarium tumidum*) and changes in their paleoenvironment. We suggest that ΔR results showed a sea surface salinity (SSS) decrease in the islands lagoon as relative sea level have been risen during the period between ~2.6 cal kyr BP to the present, and this can be attributed as closure of the lagoon. Moreover, the maximum sea level in mid-Holocene using GIA modeling suggest that contribution of hydro-isostatic rebound to sea level changes were much smaller than previously reported values. We infer that the current rate of vertical land motion reported from instrumental observations at Tongatapu is inconsistent with the Holocene sea level record, and must have been responsible from recent tectonic events. Comparing ΔR results with paleotopographical maps, we suggest that ΔR can record the response to subtle environmental changes that cannot be reconstructed in the model. We also suggest that there is a possibility that SSS is an environmental stress factor for the growth of *G. tumidum* in Tongatapu for the past 2600 years and that this is due to the closure of the lagoon by RSL changes supporting the implication reported previously from an archaeological study (Clark et al., 2015).

Keywords: Holocene, Southern Pacific, Paleoenvironment studies, Local marine reservoir effect, GIA modelling, Bivalves

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The environmental change from lagoon sediment along Nakai Trough in Japan during the past 2000 years.

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The lagoon sediment offers critical information for sea level change because lagoon reacts sensitively with a small fluctuation of sea level. In other words, the environment change in lagoon depends on sea level fluctuation. The sediment in the lagoon in Japan was continuously deposited and offer high-resolution results such as paleoclimate change and sea level change. The environmental change was reconstructed from three lakes, Lake Hamana, Lake Kawahara, Lake Ryuuoo, based on diatom assemblage. The 16Hm-1C core was taken from Lake Hamana. The environment is divided based on diatom assemblage. Zone 1 is dominant by *Cyclotella atomus* and *C. atomus* var. *gracilis*. It is suggested that the lake was a hypersaline lake. Then the lake was changed to Oligohaline lake in AD 200. Zone 3 and Zone 4 were dominant with freshwater species. Around mid of 14th century, the lake was changed to the brackish lagoon as consequences of creating inlet and paleoriver activity. KAW2 core was from Lake Kawahara. Zone1 was typical lagoon which is affected by sea water. After around AD 550, the lagoon changed to the brackish lagoon. Freshwater species in AD 1100 dominated the lake. The RYU core got taken from Lake Ryuuoo. The environmental changed from brackish lagoon to freshwater lake in AD 600. The environmental change happened at the same time in 3 lakes. The coastal deformation resulted in change RSL (relative sea level) and environmental change in lakes.

Keywords: Lagoon, Diatom, Environmental change

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Discovery and these sources of drift pumices interbedded in coastal sediments at Sekinehama, in the northern part of Shimokita peninsula, Aomori prefecture

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Pumice, one of the pyroclastic materials, may start drifting in the sea for some reason and be carried to distal places by the tide. Pumice which started drifting is assumed to, lost its buoyancy due to the attachment of marine life or the filling of water in the pores, except the case that it is launched to the coast (Kato, 2009), and such pumice is called "drift pumice". Shiraishi et al. (1992) reported that drift pumices of Aso-4 pyroclastic flow deposits and Sambe-Kisuki pumice fall deposits existed in the upper Quaternary in Oga peninsula. In addition, 7 to 10 thousand years ago when Aso-4 and SK erupted, the possibility that there was an ocean current northward of the Sea of Japan was mentioned. Pumice drifts under the influence of topography and ocean current. Thus, drift pumice in the strata can be evidence of estimate paleoenvironment at the time of drifting.In this study, we conducted field surveys at Sekinehama in the northern part of the Shimokita Peninsula and found several drift pumices. Furthermore, here we report that the drift pumices are erupted from Ulleung island (U-2) and Towada volcano (To-Cu), which are correlated based on the major-element composition of pumices, and crosschecked by 14C dating of humus under the drift pumice layer.

Keywords: drift pumice, Towada-Chuseri (To-Cu) tephra, Ulleungdo, Shimokita peninsula

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Comparison of geological stratigraphy between three drilling cores and analysis of shallow geological structure in the Koriyama Basin, Northeast Japan

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1. Introduction

The Fukushima Renewable Energy Institute, AIST (FREA) has surveyed shallow subsurface geological analysis (ca. 100 m depth) in the Koriyama basin as part of researches to compile a suitability map for installation of ground source heat pump system. Ishihara et al. (2018) reported geological stratigraphy of an all-cores (GS-KR2015K-1, 251.60 m asl, 100 m depth) in the central part of the Koriyama basin and Kasahara et al. (2017) reported a tephro-stratigraphy of KR-11-1 core drilled in the northern part of the basin. In this study the authors reported geological stratigraphy of a new all-core (GS-KRC-1, 249.4 m asl, 80 m depth) in the southern part of the Koriyama basin and consider the shallow subsurface geological structure of the basin.

2. GS-KRC-1 core

Lithofacies: In the depth from surface to 29 m, silt and sandy-silt beds are dominant. Gravel layers are also intercalated at 3-8 m, 13.5-14.0 m, and 18-24 m depth. A tephra layer (volcanic glass ~ pumice sand beds) is detected from 27.0-27.4 m depth. Facies from 29 to 80 m mainly consist of gravel layer and a pyroclastic flow sediment is intercalated at 52-65 m depth.
Dating result: Two radiocarbon ages of wood fragments obtained from the core (1.78 and 2.12 m depth) show ca. 50,000 cal yBP, respectively. A FT age of pyroclastic flow sediment (55-59 m depth) shows 3.4± 0.4Ma.

3. Discusstion

Based on stratigraphic correlation between GS-KRC-1 and other two cores (GS-KR2015-1 and KR-11-1), it was interpreted that silty-dominant layers with a depth of 0-29 m is the upper Koriyama Formation and gravel layers with a depth of 29-52 m is the lower Koriyama Formation or the Shirakawa Formation, respectively. The age of the pyroclastic flow sediment is well correlated with the age of the pyroclastic flow sediment (3.2 ±1.3Ma) of GS-KR2015-1 (41.9-49.0 m depth), indicated that they are the same pyroclastic flow sediments.
The pyroclastic flow sediments of the GS-KRC-1 core is distributed at about 184.4-197.4 m asl, which its base level is 10 m lower than the pyroclastic flow sediment of the GS-KR2015-1 (202.6-209.7 m asl). It is indicated that terrace or hilly landform existed just before deposition of the pyroclastic flow sediments.

Keywords: Koriyama Basin, drilling core, subsurface geological stratigraphy, tephra

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Holocene geomorphic development of the Kinu river system constrained by the dissected river valleys formed after MIS 5.

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1.Introduction

Kinugawa Lowland located in the northern part of the Kanto Plain is a relatively stable area of structural movement and is characterized by fluvial terraces of different ages after MIS 10 at around the same altitude (Kaizuka 1957; Suzuki and· Koike, 2000).
Unlike the eastern and central parts of the Kanto Plain, there are few studies of this region and the paleo shoreline in the last interglacial period in this area has not been clarified yet (Sugai et al. 2013). In addition, the relation between the distribution of dissection valleys and landform development are hardly understood in the northern area of the plain.
Coupling geologic column data and terrain analysis using GIS in the Kinugawa Lowland, we discuss fluvial processes and river valley development associated with river course changes and eustatic sea level changes since MIS 5.

2. Method

Erosion Depth distribution Map (EDM) was made based on the difference between Summit Level Map and 10m DEM(GSI) by Arc GIS (ESRI).
Thickness of Holocene valley-fill deposits was measured based on the interpretation of borehole data.
Sinuosity of dissecting valleys and river course were measured by using GSI map.

3. Result and discussion

EDM shows that the Nisinire River valley (Valley B) is deeper than the present Kinu River valley (Valley A). In contrast the thickness of Holocene deposits in Valley A was thicker than that in Valley B. Sinuosity of Valley A and B were almost the same, which implies that both Valley A and B were originated from the paleo Kinu river channel A and B running on the present Takaragi river terrace area probably in MIS 4 as active and unstable channels on a large alluvial fan surface (proto-Takaragi surface). And then, the cannel A started incising to form deep valley accompanied with BG (basal gravel layer) corresponding to a decline in sea level in MIS 3 to 2 i.e. Valley A. Finally valley A has been filled with thick fluvial deposits because of abundant sediment supply from the upstream of the Kinu river system. On the other hand. the channel B became a misfit river to form a shallow valley and then gradually buried the valley during the Holocene because of the luck of the upstream of the Kinu river.

Keywords: Kinu River, Takaragi Terrace, Dissection Valley, Summit level map

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Depositional stratigraphy based on XRF, tephras and particle size analysis of core drilled in the central part of the Kanto plain, Sakai town, Ibaraki prefectural and Kuki city, Saitama prefecture (preliminary report)

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In the Kanto plain, a large frame of the topography has been formed by glacial sea level fluctuations and the Kanto basin movement caused by plate subduction. From the southwest part of Ibaraki prefecture to the eastern part of Saitama prefecture, it is the center of the basin movement and the sediments of the last interglacial period are buried underground. In this study, the distribution depth of marine stratification was investigated using the boring core excavated by the Tone River Upstream River Office at Sakai town in the southwestern end of Ibaraki Prefecture and Kurihashikita, Kuki city in Saitama Prefecture (S12 Core and KHN Core). Observation of layer phases and laser diffraction type particle size analysis, sulfur analysis using WD-XRF, and compositional analysis of volcanic glass of tephra using SEM-EDS were carried out. The S12 core, whose hole top elevation is 12.19m, consists of from deeper part, a silt layer containing a lot of shell fragments (unit 1a, b), a dark gray upper coarsening sand layer (unit 2), a slightly organic silt layer (unit 3), coarse sand mixed with scoria (unit 4) severely color-changing silt (unit 5) and loam layer containing a lot of volcanic ash (unit 6). With reference to the results of sulfur analysis using XRF, we can reconstruct topographical change as follows. it is conceivable that on the upper part of the silt layer (Unit 1) containing sea shells which are seafloor sediments, as the influence of rivers increased at the end of the maritime, delta sand (unit 2) accumulated, and sedimentary sand (Unit 4) accumulated at the stage of regression. In the silt layer containing the shellfish, it is thought that the value of sulfur increased with the upward fine granulation as the sea was at the stage of transgression. At the depths of 20 to 26 m and in the latter half of 29 m the value of sulfur became small, so there is a possibility that it was located in a brackish water area such as an estuary and lagoon at that time. Five layers containing no-weathering white pumice with a diameter of a few mm were observed at depths of 27.5 m - 28.5 m (under above-mentioned Unit1) of the KHN core, whose hole top elevation was 15.5m, named KHN 1 - KHN 5 from the shallow one. KHN 1 and KHN 2 were included in cross lamina, and KHN 3, KHN 4, and KHN 5 were in a single layer. As a result of the principal component analysis of the volcanic glass, KHN 1, KHN 2, KHN 3 may not be a single tephra but may have been deposited secondarily. KHN 4 and KHN 5 are in good agreement with the results of principal component analysis of Tanashita pyroclastic flow of Akagi Volcano, which is considered to be comparable to this. The Tanashita pyroclastic flow (Arai, 1962; Moriya, 1968, Takemoto, 1998) is compared with the Akagi Mizunuma 8 descent pumice (Yamamoto, 2016) and the descent period is supposed to be the first period of MIS 5e (Yamamoto, 2016). Therefore, Unit 1 is considered to be the bay mud layer of Paleo-Tokyo Bay deposited at the stage of transgression in MIS 5e.

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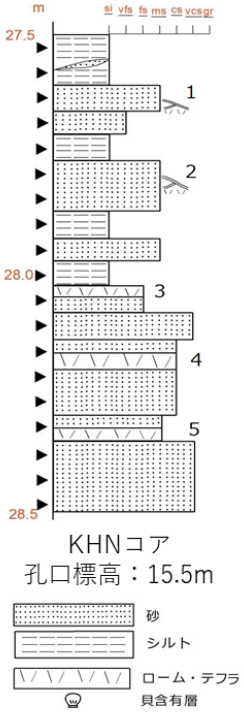
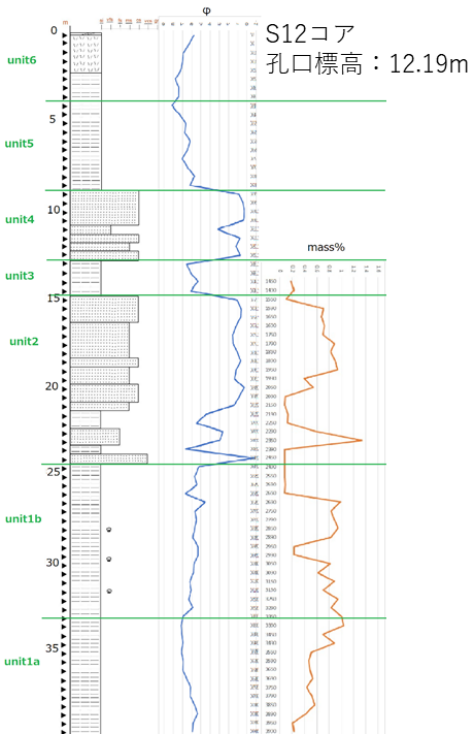
Keywords: boring core, late Pleistocene, Paleo-Tokyo bay





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Spatial distribution of Musashino Gravel in Tokyo using an automated program analyzing geological sequence from a vast number of boring data.

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Musashino Gravel is one of the supporting ground in the Musashino upland spreading in the western Tokyo, and revealing its spatial distribution is significant from an engineering point of view.
In this study, we use a new system, an ‘automated program analyzing geological sequence’ (Hori et al., 2018) from a vast number of boring data and GIS program.
Recently, according to Endo et al. (2018), division of the Musashino uplands has been revised, and subdivision of the Musashino surface has been proposed. Also, in the Funatsu et al. (2018), the inclination angle the top surface of the Musashino Gravel is suggested.
The elevation values of the upper and lower surface of Musashino Gravel, by ‘automated program’ (Hori et al., 2018) were mapped to show paleo-topography with 50m mesh.
When the upper surface of the Musashino Gravel was shown by a contour map, it was possible to clearly distinguish ridges and valleys from unevenness of contour lines. Among them, the valley topography is similar to the shape of rivers that currently flow on Musashino surface.
On the Kodaira surface (M1a) by Endo et al. (2018), the contour interval is wide and flat. The Meguro-dai surface (M1b) is gentle in the west, which is high, at the altitude of 27 m, but in other aspects the border was 30 m in altitude.
On the other hand, the bottom surface contour map of the Musashino Gravel seem that, the valley continues to the west side. But the top surface can be seen that the valley was buried by the Musashino Gravel at the west zone. Other than that there is not much difference between the topography such as valley on the top surface and bottom surface.
When comparing the obtained features with the topographic classification by Endo et al. (2018), the distribution in thickness of Musashino Gravel and the top and bottom surface contour maps are corresponded well.

Keywords: Musashino gravel layer, Musashino platform, automated program analyzing geological sequence , Borehole data

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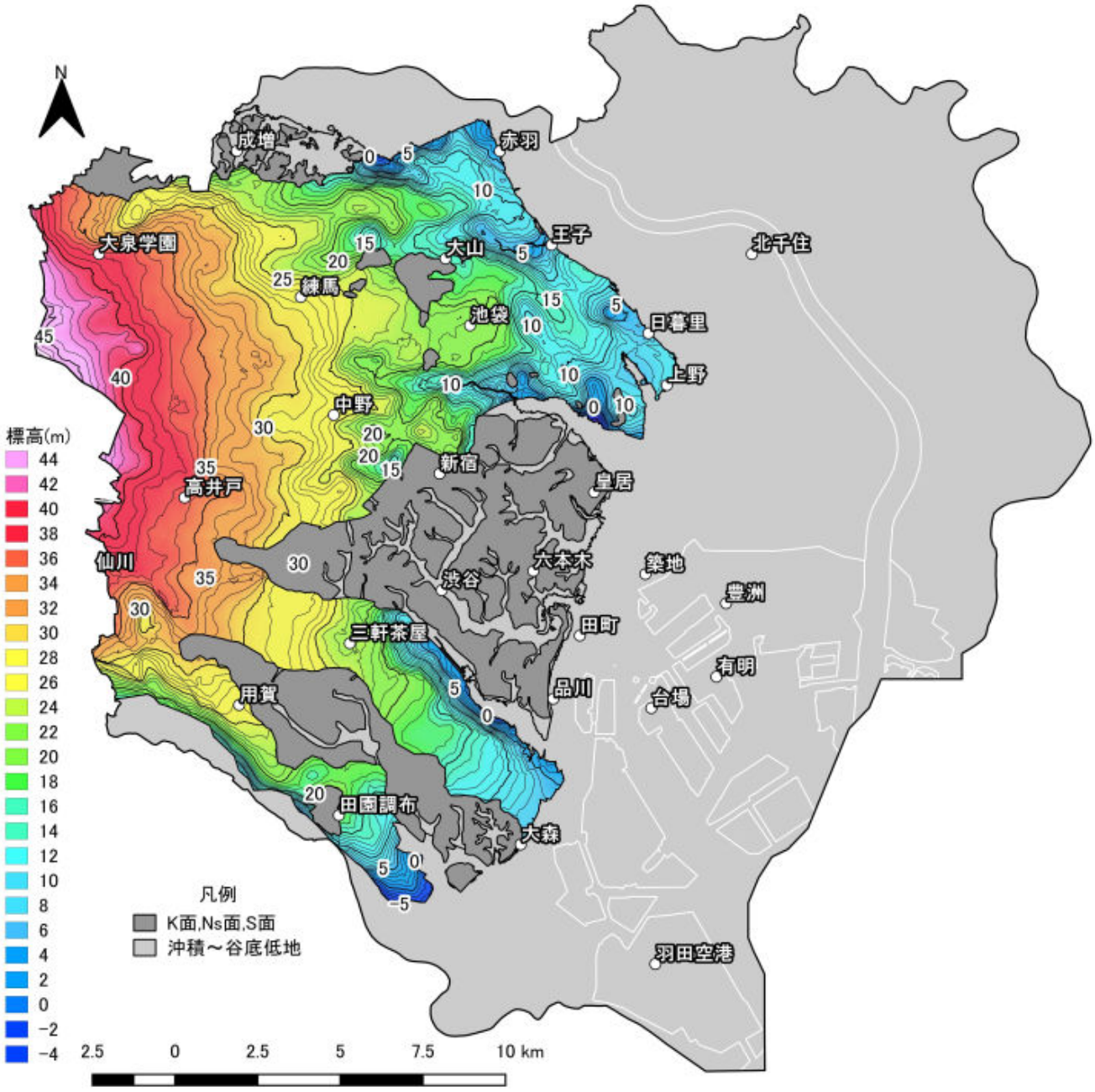

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Sedimentological features of Fuji-Sagamigawa Lahar deposits from the upper reaches of Sagami River, central Japan

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Lahar is a general term for a rapidly flowing mixture of rock debris and water (other than normal stream flow) from a volcano (Smith and Fritz, 1989). Fuji–Sagamigawa Mud Flow (Lahar) originated from the Fuji Volcano (Older Fuji) around 22 ka (Machida, 2009) distributes along the Sagami River Valley. The lahar deposits have been reported from Tsuru City, Yamanashi prefecture to Zama City, Kanagawa prefecture which apart ca. 90 km from the present Fuji Volcano summit. At least 3 events have been recognized based on field surveys by Geographical and Geological Research Group in Sagamihara City (1990). Detailed description of outcrops of the lahar deposits in the upper reaches along the Shakunagashi River, a branch of Katsura River (Sagami River) revealed that (1) the lahar deposits are divided into 6 or more units with less than 3m thick, (2) the units do not show characteristics of hyper–concentrated flow deposits, and (3) the units often intercalate parallel–cross bedded layers. These features imply that the lahar deposits in the upper reaches are formed by multiple flow events.

Keywords: lahar deposits, Fuji-Sagami River Mud Flow, Katsura River (Sagami River)

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Terrace classification and geomorphological development process around Shinano river and Uono river junction area in Niigata prefecture

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Shinano river basin has long been considered an active folding area in the Niigata prefecture. A study on the diastrophism has been research the field of geomorphology, geology and geodesy. This area river terrace spreads. It has been reported that abnormal inclination to the mountain side or the upstream side of the river due to the active fold area. In the Uchigamaki area located near the junction area of Uono river and Shinano river, relatively new river terrace formed after the AT(26-29 ka) descent period has spread. In this study, aerial photograph interpretation, field surveys, a knitting year by surrounding ruins age, and terrain analysis, for example creation of river bed longitudinal section were carried out to discuss landform evolution through chronology of river basin and crusted determination in this area.
As the result of aerial photograph interpretation, field surveys, and reference data of preceding studies, river terraces in this area was divided into 11 terraces consisting of L1 to L11 terrace in total. The Araya ruin (1.725 ka) is located on the L3 terrace. The Saigura ruin (1ka) is located on the L7 terrace. The cross section along river of terrace was created using 1m grid DEM by Lidar data. Creating a river bed longitudinal section of the Uchigamaki area showed a northeast inclination in all aspects. Focusing on the inclination degree of each surface, the L1 surface to the L5 surface are steeper than the current riverbed. and the L6 and subsequent surfaces showed a gentle slope.
Generally, higher terrace ratio to riverbed is older. The Shinano river side could divide into many terraces but Uono river side couldn`t it. The riverbed longitudinal section in Uchigamaki area showed a northeastward tilt in all terraces. That`s why, these river terraces formed by Shinano river.
In addition, there is a decline in the sea level as a factor of formation of the river terrace. Kaizuka (1977) suggest, in the middle watershed, the river terrace formed in the glacial period is steeply inclined and is buried in the gradual inclined it formed in the post glacial period. Purpose based on this area, before the L5 terrace, it was formed during the glacial period because of the steep slope, but it is suggested that it could be buried in the L6 terrace formed in the post glacial period.
As the results of consideration flow path change of the Shinano river is as flows. Originally flowed southeastward around the Uchigamaki shrine from the northeast direction and had joined the Uono river at Aikawaguchi. The river changed the flow from the west to the east as it took off at L1, L2 terrace. The river began meandering from the time the L3 terrace was separated until 1.725 ka. After L6 terrace separated the river turned from the southwest to the northeast direction which is close to the current flow path It is thought that the water flowed out after the L7 terrace until 1ka and became the current flow path.

Keywords: Shinano River, Uchigamaki, Terrace division, Vertical section of riverbed

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Estimation of the Source of Sand Beach Sediment in Tsuruga Bay, Fukui Prefecture: Focusing on Grain Size Analysis and Composition of Clastics

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In order to clarify the dynamics of the beach sand in the sandy coast of Tsuruga Bay, we carried out grain size analysis, composition of clastics and color analysis of beach and river bed sediments. The west coast of Tsuruga Bay consists mainly of granitic rocks and the east coast mainly of accretionary complex. As the result we revealed that the transportation and sedimentation process along Tsuruga Bay coasts might not be closed within each coast and its inflowing rivers, but it may be influenced by the coastal current.

Keywords: sand beach sediment, grain size analysis, composition of clastics

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Characteristics of Latest Pleistocene to Holocene deposits of two cores obtained from the inner part of the Nobi Plain, central Japan

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The Nobi Plain, central Japan, is a Holocene fluvial–coastal plain formed mainly by the Kiso, Nagara, and Ibi rivers. This poster shows sedimentary characteristics of cores KG and OZ obtained from the inner part of the plain. Two cores were taken from the present floodplain of the plain where prodelta deposits are not distributed. The borehole sediments were divided into depositional units based on lithology, water content, color, mud content, radiocarbon age, and fossil diatom. KG1 and OZ1 are channel deposits composed mainly of sand and gravel. KG2 and OZ2 consist of silt to medium sand estimated to have accumulated under intertidal/subtidal environment near the river mouth, and overlay KG1 and OZ1, respectively. KG3, characterized by organic-rich mud, covering KG2 is interpreted as floodbasin deposits. OZ3, overlies OZ2, consists of coarse sand to very fine sand, and the upper part shows a fining-upward succession. This unit may have been formed under in-channel and point bar environment.

Keywords: sedimentary environment, radiocarbon age, floodplain, Holocene, Nobi Plain

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Subsurface distribution of marine deposits during the MIS 5e and vertical displacement inferred from microfossil evidences and borehole logs in northern Ise Plain, central Japan

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This study identified Marine Isotope Stage [MIS] 5e marine deposits inferred from borehole logs, diatom and pollen fossil analyses and radiocarbon ages for estimation of vertical displacement in the northern Ise Plain, western coast of the Ise Bay. Late Pleistocene marine and riverine terraces are distributed widely in the northern Ise Plain (Ishimura, 2013). In the northern Ise Plain, active faults, including the Yoro-Yokkaichi Fault Zone and Eastern margin Fault Zone of Nunobiki Mountains, are distributed at the boundary between Pleistocene terraces and alluvial lowland. Although the study area, southern part of Suzuka City, is located at the boundary of both fault zones, activity and tectonic relationship of them are unclear. Therefore, we performed geomorphological classification by interpretation of aerial photos, analyses of borehole logs, diatom and pollen fossils to identify MIS5e marine deposits.

Late Pleistocene terraces, middle and lower, are distributed in the study area, which was deformed in their eastern margins by active faults. The top of middle terraces has 5 to 15 m T.P. and corresponding to older middle terrace (tm1) of Yoshida (1987) and Kambe terrace (tmk) of Yoshida (1984). The eastern margin of middle terrace around the Ozaga-ike pond shows flexure structure, indicating that active faults are distributed at the boundary between the middle terrace and alluvial lowland.

Late Pleistocene deposits were able to be divided into three units, Unit A to C in ascending order, and the Unit B subdivided into four subunits (B-1 to 4). Unit A is composed of solid sandy and muddy deposits with freshwater diatom species, which suggesting that this unit is a part of Pliocene Tokai Formation. Unit B is composed of alternated layers of muddy and sandy sediments; Subunit B-1: marine muddy sediment, Subunit B-2: sandy sediments, Subunit B-3: freshwater muddy sediments with abundant freshwater diatom species and plant materials showing radiocarbon ages of 50,440±760 yrBP and >53,940 yrBP, Subunit B-4: gravelly sediments, corresponding to surface gravelly deposits of the middle terraces. Unit C is alluvium deposits, soft and humic muddy deposits. The subunit B-1 has abundant brackish to marine water diatom species and Lagerstroemia pollen, suggesting that this unit deposits during the MIS 5e.

The distribution pattern of MIS 5e marine deposits, subunit B-1, is possible to indicate vertical displacement since the MIS 5e, ~120ka. Elevation of the top of the subunit B-1 is ~-13.5 to −15.5 m T.P. in western side of the presumed fault, and ~-17. 5 m T.P. in eastern side. Therefore, vertical displacement is estimated to be more than 2 m, and vertical slip rates since the MIS 5e are suggested to be 0.02 m/kyr. In addition, the bottom of the subunit B-3 suggest that vertical displacement is more than 6.5 m, and vertical slip rate is more than 0.05 m/kyr. There estimated values is similar to the slip rate of the Chisato Fault, northern margin of Eastern margin Fault Zone of Nunobiki Mountains, 0.05 to 0.21 m/kyr (Mizutani, 2017).

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Keywords: MIS5e, diatom fossil assemblage, pollen fossil, Yoro-Yokkaichi Fault Zone, Eastern margin Fault Zone of Nunobiki Mountains, subsrface geology

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Detection of the Amagi-Kawagori tephra (Kg) in the Shijima lowland, the Shima Peninsula, and its significance to reconstruct tsunami history

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The coast from the eastern to the southern part of the Kii Peninsula facing the Nankai Trough is located near the boundary between the Tonankai and the Nankai Segment of the past large earthquakes. Therefore, reconstruct of the tsunami history in this area is very important for evaluating the rupture area of the past Nankai Trough Earthquake. Tsunami deposit surveys have been carried out in marshes and lagoons along the coast, but it is difficult to correlate between each survey site. Here we report that the Kg tephra (around 3100 cal yBP), which is effective wide-spread tephra as a key to the correlation of the tsunami events, was found in marsh deposit obtained from the excavation survey at the Shijima Lowland, the Shima Peninsula.

In the Shijima Lowland, Fujino et al. (2018) identified ten sand layers (Sand A - J) recording tsunami history in marsh deposit. In this study, we carried out excavation survey using hand corer to a depth of 483 cm at the lowland, and detailed microscopic observation to each 5 cm thick samples from the obtained core. As a result, pumice type volcanic glass was detected from the depths of 265-270 cm and 275-280 cm. Particularly in the vicinity of 276 cm in depth, about 5 mm thick of pale white layer can be observed visibly. Also, from the A2 core in Fujino et al. (2018), about 5-8 mm thick of pale white layer in the organic silt between Sand G and Sand H was identified, and the same type of volcanic glass was detected.

Measuring the refractive index of these volcanic glasses using MAIOT, the counted value was concentrated in the range of 1.499 to 1.501, which is well-matched to the value of the Kg tephra (1.495-1.502) proposed by Machida and Arai (2003). Component analysis data by EDX performed by Furusawa Geology Ltd. is also consistent with previous research results on the Kg tephra.

The detected horizon of the Kg tephra in the A2 core constrains the age of Sand G and Sand H. As a result of this study, it can be estimated that those are 3100-2740 cal yBP and 3600 - 3100 cal yBP respectively.

In the southernmost part of the Kii Peninsula, Kitagawa et al. (2017) reported the Kg tephra detected from coastal marsh deposit intercalated between event sand layers whose ages were estimated to be 2950-2470 cal yBP and 3390-3100 cal y BP respectively (Shishikura et al., 2014). These sand layers can probably be correlated between two sites. The Kg tephra is an important key to reconstruct the tsunami history along the coast of the Kii Peninsula, and it is expected to clarify the occurrence pattern of the Nankai Trough Earthquake.

Keywords: Shima Peninsula, Shijima Lowland, Nankai Trough, Amagi-Kawagodaira tephra, tsunami history, tsunami deposit

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Holocene paleoenvironmental changes based on biomarker analysis at the western part of the Kawachi plain, Osaka, Japan

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1. Introduction

To reconstruct past environmental variation in the Quaternary strata of the Osaka plain, analysis of microfossil assemblages such as foraminifera and ostracods have been conducted by previous studies (e.g., Umeda et al, JPGU2018). Although these microfossil assemblages provide estimates on the hydrospheric environments, their occurrence is mainly limited to marine deposits. In this study, the organic biomarker molecules derived from terrestrial and aquatic organisms have been investigated in the Holocene sediments of Sakuranomiya East drill core to reconstruct the past variations in the source of organic matter (OM) and depositional environments at the western part of the Kawachi plain.

2. Analytical methods

Biomarker analysis was performed on the 20 sediment samples of an 18 m long Sakuranomiya East core, which have been drilled at Sakuranomiya East park (altitude + 0.5 m), Miyakojima, Osaka City. The Sakuranomiya East core is consist of the Holocene Nanba Formation and divided into 4 units; the lower unit (SH-1; altitude -19.50 to -17.60 m) consists of medium sand to mud layers, SH-2 (altitude -19.50 to -17.60 m) consists of medium sand to fine sand layer, SH-3 consist of mud layer (SH-3: altitude -16.00 to -8.90 m), and SH-4 (altitude -8.90 to -1.60 m) consists of mud to fine sand layers. Biomarker analysis was performed at 20 horizons spanning SH-1 to SH-4 including mud and sand layers. Lipids were ultrasonically extracted from sediments with dichloromethane and methanol, and subsequently divided into 3 fractions (hydrocarbons, ethers/esters/ketones, and polar lipids), then analyzed by GC and GC-MS. Polar fractionation was derivatized prior to analysis. Compounds were identified based on mass spectra and relative retention time and quantified with GC-FID.

3. Results and discussion

n-Alkyl lipids (*n*-alkanes, *n*-alcohols, *n*-fatty acids) and terrestrial plant biomarkers such as friedelin and sawamilletin were identified as major compounds. The predominance of long-chain ($>C_{22}$) *n*-alkanes and *n*-alcohols with a significant amount of terrestrial plant biomarkers indicated the overall predominance of terrestrial OM throughout the studied core. This is reasonable considering that the core site is located in the incised valley of the paleo-Yamato River (Mitamura and Hashimoto, 2004). Meanwhile, the amount and chain-length distributions of biomarkers also reconstructed variations in the contribution of fluvially transported terrestrial OM. The decreasing long-chain components of *n*-alcohols from SH-1 to SH-2 were considered to coincided with sea-level rise; rapid expansion of inner bay over the Kawachi plain increased a distance from the retreating estuary which supplied terrestrial OM. The high relative concentration of sawamilletin observed in SH-2 might reflect the input from coastal Graminae vegetation at 8ka. The gradual increase of long-chain *n*-alcohols in the upper SH-3 to SH-4 initiates around the highest sea level period of ca. 6.4 ka indicating the increasing fluvial input of terrestrial OM with the progradation of river delta. In addition, an increased *n*-alkane Paq index observed in SH-4 suggests the higher input of aquatic macrophytes at ca. 4ka. In the upper part of SH-3, a higher contribution of short-chain *n*-fatty acid ($< C_{21}$) were observed. Short-chain *n*-fatty acids are considered mainly derived from aquatic organisms including planktons and bacteria. Oshiro (2018MS) estimated the bottom environment of these horizons as closed inner bay and reported the occurrence of *Buccella frigida*, detritivore foraminifera frequently occur in OM

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rich bottom sediments. Therefore, the upper part of SH-3 is characterized by the enhanced marine production along with increasing terrestrial OM input, probably deposited under the influence of estuary circulation.

Keywords: Biomarker, Osaka plain, paleoenvironmental changes

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Environmental change before and after Kikai-Akahoya tephra descent in the Miyazaki plain, Southern Kyushu

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In the early Jomon period (ca. 7.3 ka), a large Koya pyroclastic flow reached the southeastern Kyushu was reached by the eruption that occurred at the Kikai caldera about 40 km off the southern edge of the Osumi Peninsula. At this time the fine grain ash which blew up in the sky is called K-Ah tephra and it is known that it has reached the Tohoku region. Kawahata has reviewed the research on the age of the K-Ah tephra so far, also studied the positioning of the tephra in the elders of the archeology, and have considered how the K-Ah eruption had an impact on human beings and other ecosystems (Kuwahata, 2013). In this report, since the boring survey was conducted on the alluvial deposit of the Miyazaki plain where the K-Ah tephra was thickly deposited, we will report the outline of our study.
In the Miyazaki plain, the K - Ah tephra of the first deposit is 20 to 30 cm thick and is observed as a mild to fine grainy glassy falling volcanic ash. On the other hand, secondary sediments found in alluvium deposits are thickened to about 2 m in thickness due to the influence of water flow, and are composed of gray medium grain glassy volcanic ash which has been culled out. The cause of thickening of the secondary sediments of K - Ah tephra was caused by debris flow or flood flow accompanying the collapse of mountainous and hilly slopes where land - based vegetation died due to ash falling and lost water storage function Nagaoka et al. (1991) had estimated that there was. In recent years, the hypothesis that the sand layer of the K-Ah base is a tsunami event deposit immediately after the tephra ash fall has also been shown by Matsuda et al. (2016).
In July 2017, we carried out an all-core bowling in the Ikumenomori Sports park of Miyazaki City. As a result, it was possible to collect cores up to the excavation length of 15.55 m from the surface. We are conducting various analyzes such as tephra analysis, radioactive carbon dating, pollen analysis, diatom analysis, seed analysis, plant silicate analysis, shellfish analysis, foraminiferal analysis, etc., using the collected cores.
Core stratigraphy is divided into five layers A to E. Dark gray organic soil (A layer) directly beneath the embankment, gray silt layer of peaty (B layer), water deposit of K-Ah (C layer), secondary sediments and events of K-Ah tephra Sand layer (D layer), gray silt layer containing shell pieces (E layer). As a result of various natural scientific analyzes of the core, it became obvious that the K-Ah tephras secondary sediments are almost composed of bubble type volcanic glasses, and the base event sand layer includes not only K - Ah but also Aira It was also found to contain volcanic glass originating from Aira-Tn (AT) tephra. Therefore, the estuary environment has been occurred in the Miyazaki plain caused by the Jomon transgression, and it has been buried rapidly due to the secondary deposition of K-Ah, and changed to landenvironment drastically.

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Keywords: Kikai-Akahoya eruption, Miyazaki plain, Environmental change, Souhern Kyushu

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The history of volcanic eruption based on tephrochronology at Plio-Pleistocene in Japan :2 Chronology of pyroclastic flow deposits in southern Kyushu

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The frequency and the scale of the large volcanic eruption in the Japanese Islands are one of the important problems in the forecast of the long-term geosphere stability. The restoration of the history of the large volcanic eruption in the late Pleistocene has been examined by the correlation with the pyroclastic flow deposit and the distal fine ash (For example, the Ito pyroclastic flow deposit and the comparison with the AT volcanic ash of 30ka : Machida and Arai, 1974, etc). However, an older age, a lot of source volcano cannot be specified and the evaluation at the scale and age of a volcanic eruption are difficult.

In tephrochronology, identification and the comparison of the tephra based on the chemical composition analysis of mayor and trace elements of the volcanic glass from the 1990's (Yoshikawa, 1990). As a result, the comparison accuracy of an older pyroclastic flow deposit and the tephra in the remote place improves. It has come to obtain information on the large volcanic eruption the widespread tephra correlation at 5 Ma-1Ma in central Japan (Mizuno, 2000; Tamura and Yamazaki, 2004 and Satoguchi and Nagahashi, 2012). Mizuno (2001) showed that the source volcano area of the widespread tephra was definable to Chubu Sangaku, Kyushu, and Tohoku region from the element characteristic of a trace element of volcanic glass of the pyroclastic flow deposit to some degree. Tamura and Yamazaki (2015) reported on a petrology feature, the eruption scale, the source and the age of the tephra about 36 widespread tephra layers of 5Ma-1Ma. The Tohoku origin tephra layers are concentrated on 2Ma-1Ma and the Chubu Sangaku origin tephra concentrates on 3Ma-1.5Ma. The other side, in Kyushu and Hokkaido, there are a lot of Pliocene-early Pleistocene pyroclastic flow deposits to which the comparison with the distal tephras is not done. For the construction of the volcanic eruption, we are to advance the tephra research on Hokkaido and Tohoku where information is especially little. This study has correlated with pyroclastic flow deposits distributed in southern Kyushu and widespread tephras Pliocene and early Pleistocene.

In the late Pleistocene, the volcanic eruption was gushed in southern Kyushu and, a large amount of pyroclastic flow was gushed. As a result, the old age pyroclastic deposits are hidden under a cover, and it is difficult of tephrochronology of the pyroclastic flow deposit at early Pleistocene and Pliocene of southern Kyushu (Miyaji and 1987). Mizuno et al.(2017) examined the comparison with widespread thephras that the feature of the Kyusyu origin and pyroclastic flow deposits in southern Kyusyu. The Sendai pyroclastic flow deposit (Snd: Ohta, 1971) correlated with Habutaki1-MT2 tephra (Hbt: 2.9Ma: Tomita and Kurokawa, 1999; Tamura et al., 2016) and the Akune1 pyroclastic flow deposit (Akn1: 3.3Ma: Miyaji, 1987) correlated with Tsuchimaru2 tephra (Yoshikawa, 1975), Biroku1 tephra (Yoshikawa, 1988), TenjinikeL2 tephra (Yoshikawa and Ozaki, 1986) . In southern Kyusyu, the volcanic eruption was active in about 3Ma. This research investigated, described the pyroclastic flow deposits of the Koriyama Formation at Yaeyama area, Kagoshima Prefecture and tried to correlate with two pyroclastic flow deposits and the widespread tephras at Plio-Pleistocene.

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The Miyawaki pyroclastic flow deposits (Myk: Uchimura et al., 2007) is thickness of about 5m and white fine grain, unremarkable pumice in the type locality. Myk is containes hornblende, orthopyroxene and a small amount of biotite and clinopyroxene. The K-Ar age of Myk is 2.88±0.16Ma, 2.71±0.16Ma (Uchimura et al., 2007). The new tephra found in Yamanouti village, Sendai City is called Ymn is thickness of about 10cm and white fine grain. Ymn mainly consists of glass shard bubble-wall type with hornblende and orthopyroxene as phenocrysts. The chemical composition of the glass phase in these tephras, Myk is characterized as poor in CaO (0.9%) and rich in K_2O (4.3%) and Ymn is characterized as rich in CaO (1.6%) and poor in K_2O (3.4%).

There are Sunasaka tephra (Sns: Yokoyama et al., 1979) of the Kobiwako Group and Mori tephra (Wada, 1978) of the Tokai Group as a similar tephra to the age and the chemical composition of the glass phase of Myk. However, biotite is not contained in Sns and Mori. The problem remains in the correlation. As for Asashiro-Tomoda2 tephra (Ass: 2.6Ma: Tamura et al., 2008), a chemical composition of the glass phase and mineral composition is similar to Ymn. Ass exists in the upper Hbt1 in central Japan such as Osaka, Kobiwako and Hokuriku Groups. The possibility that Ymn is compared with Ass is high. A further investigation will be hoped for in the future.

Keywords: Widespread tephra, Plio-Pleistocene, History of volcanic eruption, Southern Kyusyu, Pyroclastic flow deposit, Chronology

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Identification of Ks5 tephra and similar tephras based on trace element composition of volcanic glass shards

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1. National Agriculture and Food Research Organization, 2. National Institute of Advanced Industrial Science and Technology, 3. Central Research Institute of Electric Power Industry, 4. FURUSAWA Geological Survey

Some vitric ash tephras of the middle Pleistocene are similar in major element composition of glass shards and difficult to discriminate. In this study, we examined indices to distinguish them using the trace element composition of volcanic glass shards.

Nanayama and Nakazato(2018) focused the BT72 tephra which horizon was above MIS11 and the Ks5 tephra which horizon was under MIS11. Then they correlated these tephras and pyroclastic flow sediments in southern Kyushu. As a result, they found differences in the trace element composition of glasses of BT72, Wakimoto and Ks5, and showed that tephras similar to Ks5 were intercalated in three horizons.

In this study, we added the analysis of K1-175 and K1-223 tephras of the Higashinada core (Yoshikawa et al., 2000) which were the Ks5-like tephra, and the significance (5% level) of the difference in analysis mean values of trace components was analyzed by Tukey-Kramer test (Maruyama et al., 2017) and reconsidered the correlation of these tephras. LA-ICP-MS of volcanic glass shards was quantitated for 34 elements from Sc to U by the procedure of Furusawa et al. (2018) and investigated 32 elements except Cr and Ni with large variations. The ratio of the number of elements with no significant difference between BT72 and Wakimoto for Ks5 is 53%. And that of Wakimoto about BT 72 is 56%. Such an examination is considered to be an identification index of these tephras. On the other hand, the combinations of which the ratio of the number of elements with no significant difference is 75% or more are Hegawa pfd, Ogoyama tephra, and K1-223 for Ks5, Oda pfd for Wakimoto, K1-175 for BT72. These tephras are considered to show high similarity.

Since K1-223 is intercalated to low sea level horizon between marine clays of the Osaka Group, correlation with Wakimoto is predicted, but here it is correlated with Ks5. It is necessary to accumulate these analysis data in the future and to study the source pyroclastic flow deposit of BT72.
References: Furusawa et al.(2018) Jour. Geol. Soc. Japan,124(6); Maruyama et al.(2017)Quaternary International,456; Mizuno(1997)Earth and Planetary Science Society Joint Meeting Abstructs; Nakazato et al.(2005)JAQUA meeting Abstructs,35; Nanayama and Nakazato(2018)Jour. Tokyo Geogr. Soc.,127(6); Nishizawa and Suzuki(2017)JpGU-AGU abstructs 2017; Suzuki(1999)Geol.Soc.Jap.106th meeting abstracts; Yoshikawa et al.(2000)Daiyonki-kenkyu,39(6)

Keywords: LA-ICP-MS, U-Pb age, tephra

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Climate, vegetation and fire history of the last ~100 ka from archaeological sites of Belan valley, north-central India

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Late-Paleolithic to Neolithic archaeological sites situated in north-central India is known for its well-preserved artifacts and the first evidence of domesticated rice (*Oryza sativa*) from the Indian subcontinent. Therefore, these archaeological sites provide an ideal platform to understand the linkage of hominins with climate, vegetation and fire events during the late Quaternary period. As the fire disturbance in the modern ecosystem appears to be one of the important processes in shaping vegetation and landscape dynamics, its identification in paleo-records would enhance our understanding of the past environment. However, climate, as well as human, can equally induce the fire at the stand. Therefore, unraveling the natural and hominin induced factor is equally important to comprehend the paleoclimatic and paleovegetation conditions at a regional and global scale.

In this study, 49 paleosols sampled from six archaeological sites of Belan River. Paleosols were analyzed for *n*-alkane distribution, $dD_{n\text{-}alkane}$, $d^{13}C_{n\text{-}alkane}$ value and Charcoal count to reconstruct the climate, vegetation and fire events. *n*-Alkane distribution pattern, carbon preference index ($CPI_{25\text{-}33}$) and average chain length ($ACL_{15\text{-}33}$) used to delineate the source of organic matter (OM) in the paleosols which suggest a dominant contribution from terrestrial plants. Three samples of lower $CPI_{25\text{-}33}$ (~1.0) and $ACL_{15\text{-}33}$ (~23.0) observed that indicate enhanced degradation of OM. The lower $CPI_{25\text{-}33}$ sample showed a prevalence of mid to short-chain even-numbered carbon (maximum at *n*-C_{16} or n-C_{18}) which was also observed in the previous study from the archaeological site for fire events (Eckmeier et al., 2009). Additionally, macro-charcoal analyses (n=40) showed degraded paleosols exhibits higher charcoal which endorses its exposure to fire. The macro-charcoal analysis suggests paleofire events in the Belan valley at i) ~58ka BP, ii) ~26ka BP and iii) ~8ka BP. $dD_{n\text{-}alkane}$ values suggested lower rainfall condition during Large Glacial Maximum (LGM; ~20-25ka BP) and during the early-Holocene (~11ka BP). The intensification in rainfall observed at i) ~60ka BP, ii) ~26ka BP and iii) ~10-3ka BP which corresponds to observed fire events. The $d^{13}C_{n\text{-}alkane}$ values showed the dominance of grassland between ~30-25ka BP with the cool and dry environment due to LGM which was favorable for wildfires. Further, the fire event at ~26ka BP identified at Main Belan temporarily overlaps with Mahagara and Koldihwa archaeological site. The absence of any major sign of thermal alteration of paleosols (supported by *n*-alkanes) in Koldihwa and Mahagara with indicates the local nature of the paleofire events. Similarly, fire events observed in this study coincides with the high rainfall condition which is unconducive to natural wildfires. Further, fire disturbance increases in the early Holocene to mid-Holocene overlaps with the timing of domestication of agriculture in the Belan valley. Therefore, this study postulate that the paleofire events were mostly induced by hominin groups living in the Belan valley.

E. Eckmeier., GLB.Wiesenberg., 2009. Short-chain *n*-alkanes (C_{16}-C_{20}) in ancient soil are useful molecular markers for prehistoric biomass burning. Journal of Archaeological Science, 36, 7, 1590-1596.

Keywords: Archaeology, Stable Isotope, n-Alkane, Late Quaternary, Charcoal

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[E] Poster | H (Human Geosciences)：H-SC Social Earth Sciences & Civil/Urban System Sciences

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_10

[H-SC06] Role of Geosciences for sustainable use of marine and coastal ecosystems in urbanized world.

convener:Kalpana Chaudhari(Institute For Sustainable Development and Research)

As per the United Nations estimates, the world population reached 7.3 billion as of mid-2015, implying that world has added approximately one billion people in the span of the last 12 years. The total population on earth is predicted to increase by more than one billion people within the next 15 years, reaching 8.5 billion in 2030, and to increase further to 9.7 billion in 2050 and 11.2 billion by 2100. Urban planning and management plays an important role in achieving the social sustainability through geosciences, environmental sustainability for urban transformation. Over the next generation of greatest increase in population, in production and in poverty will occur in cities in Asia and Africa. Due to this rapid urbanization and industrialization, the problems of urban organizational management, which often linked with geosciences and other socio-political aspects include, management of different urban planning and management, disaster management and resources mobilization, coastal zone management etc. for sustainable urban development will need better understanding of geosciences and linked with societal issues .Therefore it would be necessary to study the urban policies for sustainable development in Developed countries in Europe, Asia-Pacific and its impacts on the public life and also on the social-economic development of the urban region through systematic study of geosciences. This joint session will open up the opportunity for the researchers, scientists and students from AGU, EGU and AOGS to present their research/case studies on this topic and to network for future joint research programs. The joint session focuses on policy formulation for resources planning, coastal risk and vulnerability, social-ecological vulnerability and disaster resilience in coastal communities, Human Pressures on Coastal Environments, land water-seawater interactions for sustaining urban development in Asia-Pacific, Europe, South America and Africa region.

[HSC06-P01] Research on Diffusion Method of Factor in Urban Land Classification

★Invited Papers

*Jun Zhou[1] (1.Tianjin Normal University)

[HSC06-P02] Assessment of facilities for green tourism in Japan: Fifty-six indices in eight regions using online data

*Hanqiu Zhang[1], Qiongying Xiang[1], Jiaying Shi[1], Junchi Zhang[1], Yingming Mao[1], Kyung-hun Min[1], Ge Chen, Tokiya Oka[1], Zijiao Xie[1], Minami Kashima[1], I Made Pradnyan Dana Natawiguna, Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

[HSC06-P03] Study on Green Tourism Experience —— Cases of Popular Strawberry Farms in Chiba Prefecture

*Yilin Wu[1], Mengying Gao[1], Kazuhei Sato[1], Tingyu Lu[1], Fumeng Zhang[1], Siqi Xing[1], Karolina Brandt[1], Mai Uemura, Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

[HSC06-P04] **Ritual plant utilization in landscapes planning. Case study: Riverside in Denpasar City.**

*I Made Pradnyan Natawiguna[1], Katsunori Furuya[1] (1.Graduate School of Horticulture, Chiba University)

Research on Diffusion Method of Factor in Urban Land Classification

*Jun Zhou[1]

1. Tianjin Normal University

In urban classification, it is rather difficult and complex to calculate the classification factor diffusion. The purpose of this paper is resolve calculation efficiency in more barriers and more pass points condition. Topological processing of obstacle and evaluation extent to generate more evaluation zonings, use Dijkstra algorithm to calculate the shortest distance between any two pass points in advance. The method successfully resolve the spatial operation as distance operation, can effectively resolve calculation efficiency. A case study in Jilin province in 2016 show that the technical roadmap is feasible, and the results are reasonable

Keywords: evaluation zoning, urban land classification, obstacle, diffusion, shortest path

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Assessment of facilities for green tourism in Japan: Fifty-six indices in eight regions using online data

*Hanqiu Zhang[1], Qiongying Xiang[1], Jiaying Shi[1], Junchi Zhang[1], Yingming Mao[1], Kyung-hun Min[1], Ge Chen, Tokiya Oka[1], Zijiao Xie[1], Minami Kashima[1], I Made Pradnyan Dana Natawiguna, Katsunori Furuya[1]

1. Graduate School of Horticulture, Chiba University

Background and Objectives

Green tourism is a dynamic and growing global trend. Cities are seeking ways to development by building tourism based on sustainable, environmentally friendly, and responsible activities. City planners are increasingly aware of the great possibilities of the relationship between tourism and cities' natural environments. This study's goal was to develop an objective assessment of green tourism regarding non-human conditions. A scientific evaluation might reveal the specific tourist attractions or places that receive the most tourist attention in Japan.

Methods

The Green Destinations Standard (available on the Green Destinations website) was modified for the purposed assessment. After studying and modifying the standard of green tourism, two types of variables were chosen for the analysis: dichotomous variables (indicators) and continuous variables. The indicators were nature conservation, facilities, popular seasons, management, and resources. The continuous variables were access (types of transportation), capacity/volume (numbers of tourists), and average cost (JPY). We found eight cases of green tourism in eight different regions of Japan and coded their data into the variables for the analysis. Ultimately, 56 indices were created.

The data were analyzed using reliability analysis, binary variables, and descriptive statistics in JASP software. The reliability analysis determined the reliability of the data, and the binary variables assessed the data regarding non-human conditions. The descriptive statistics were used to assess green tourism in the different regions of Japan regarding non-human conditions.

Results

The reliability analytical results were not satisfactory, and the reason might be that the alpha reliability test was not appropriate for binary data. The binary variable and descriptive analyses were performed to assess the data.

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First, it seemed that nature conservation was a necessary condition for green tourism because the mean of this variable was 0.88. The data indicated that green tourism in Japan was mainly about the development of nature, and protecting cultural heritage was a less frequent response. Second, most of the areas had perfect and diverse methods of transit, including bicycles, cable cars, boats, walkways, and tourist buses. Although Japan has many mountains and seas, there were just a few cable cars and boats. The tourist attractions were easily reached by walking to them. We concluded that, when Japan developed green tourism, it first considered people's needs and convenience. In addition, most areas were government-managed, although a large proportion was privately administered. Last, the mean amount of tourism for the winter season was low (0.71), which was the lowest mean among the seasons. Apparently, although there are holidays in the winter, green tourist attractions open during the winter is less attractive. (**Table 1.** Descriptive statistics)

Conclusion

In sum, the scores were summarized by region. The highest score computed by the binary variable method was in the Chuba region, and the lowest score was in the Shikoku region. The Kansai cultural center and the Kanto economic center were not major areas of green tourism. If we have an opportunity to conduct in-depth research to explore this phenomenon, our findings might benefit the development of green tourism in Japan. (**Figure 1**. Total scores by region)

Keywords: Green tourism, assessment, binary variable, Japan

Table 1. Descriptive statistics

Descriptive Statistics														
	Nature Protection	Bicycle	Pedestrain	Cable car/ Rope way(Mountain)	Tourism bus/ Train	Water transport	Spring	Summer	Autumn	Winter	Official	Private	Natural	Cultural (Heritage)
Valid	56	56	56	56	56	56	55	56	56	56	56	56	56	56
Missing	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Mean	0.8750	0.5179	0.9643	0.1607	0.6071	0.3750	0.9091	0.9286	0.8929	0.7143	0.8750	0.5536	0.9286	0.6786
Std. Deviation	0.3337	0.5042	0.1873	0.3706	0.4928	0.4885	0.2901	0.2599	0.3121	0.4558	0.3337	0.5016	0.2599	0.4713

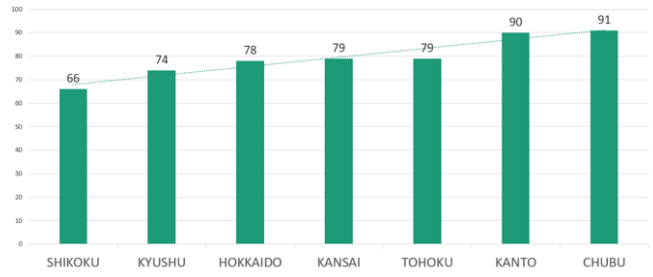

Figure 1. Total scores by region.(The full score is 112 points.)

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Study on Green Tourism Experience ——Cases of Popular Strawberry Farms in Chiba Prefecture

*Yilin Wu[1], Mengying Gao[1], Kazuhei Sato[1], Tingyu Lu[1], Fumeng Zhang[1], Siqi Xing[1], Karolina Brandt[1], Mai Uemura, Katsunori Furuya[1]

1. Graduate School of Horticulture, Chiba University

Background and Objectives

The notion of ‘green tourism’, in which people are encouraged to pursue rural leisure activities in a manner that will benefit the countryside, rather than harm, is gaining popularity. (A. Jones, 1987)

Due to today’s enormous social pressure, many people need proximity to nature in order to get recreation in their leisure time. To promote green tourism in cooperation and participation, MAFF (Ministry of Agriculture, Forestry and Fisheries, Japan) arranges green tourism experiences into five categories; farmer restaurants (to taste), local products shops (to buy), farmhouses (to stay), experience of agriculture, forestry and fisheries (to enjoy) and citizen farms (to make). (MAFF HP,2018)

Chiba prefecture is having an advantage in the location as it adjoins to Tokyo metropolitan area, this means that agriculture, fishery experiences and other wide ranges of green-blue tourism activities that can be done on a one-day-trip from the big city. Therefore, it is convenient for urban residents, travelers and visitors to interact and communicate with local farmers and valuable knowledge and experience can easily be exchanged.

Method

The research was conducted in two stages; by collecting literature information and by analysis. Chiba-ken has been chosen as the study area because of the rich nature and beautiful seascape from three sides surrounded. We chose strawberry farms for research because in recent years strawberry picking has received more and more attention and formed a new trend.

Results and Considerations

According to statistics, it is concluded that the largest agricultural experience project in Chiba prefecture is the strawberry picking (Table). The area with the largest distribution of strawberry farms is Kimitsu area, and especially Kimitsu city (Fig.1). Through the study, we found the main reasons for the prosperity of strawberry picking agriculture in this specific area. First, Kimitsu city as a historic strawberry production area has superior geographical conditions. It is possible for the visitors to do the sightseeing in a one-day-trip as the ride is about one hour from Tokyo or Kanagawa when using the Tokyo Bay Aquarain/Tsuchiyama Auto Roadway (Fig.2). Another crucial reason is the strong support from the agricultural office on the improvement of cultivation technology and management improvement of producers. Producers in Kimitsu city are working diligently and making efforts by participating in a

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workshop held by ‘JA Kimito Strawberry Committee’.

As a kind of agricultural management, sightseeing farms are often used as a sideline by farmers. Therefore, facilities and services are often inadequate from a tourism perspective. Sightseeing agriculture in Kimitsu city has benefited from the direct sales system of strawberries, and it can be said to be a model in sightseeing agriculture. For the consideration of development within tourism agriculture, more regional characteristics should be combined, and more emphasis should be placed on promoting regional advantages.

Keywords: green tourism, agriculture, tourism agriculture, MAFF

Table over the quantity of experiences in Chiba Prefecture

Activities	Strawberry	Sweet Potato	Bamboo Shoot	Rice	Blueberry
Amount	60	32	27	24	22
Activities	Peanut	Pear	Livestock	Flower Picked	Cauliflower
Amount	20	20	18	16	14
Activities	Corn	Potato	Grapes	Soybeans	Chestnut
Amount	13	13	12	12	12
Activities	Char-grilled	Fishery	Nature	Dairy Farm	Aquatic Food
Amount	11	11	10	9	9
Activities	Orange	Wild Vegetable	Broad Bean	Beach Comb	Shiitake
Amount	9	8	6	6	5
Activities	Loquat	Tomato	Persimmon	Fig	Apple
Amount	5	4	4	4	3
Activities	Taro	Kiwi Fruit	Melon	Carrot	Radish
Amount	3	3	3	3	2
Activities	Broccoli	Onion			
Amount	2	2			

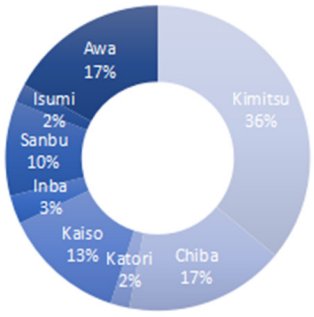

Fig.1 The distribution of strawberry fields

Fig.2 The location of Kimitsu City

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Ritual plant utilization in landscapes planning. Case study: Riverside in Denpasar City.

*I Made Pradnyan Natawiguna[1], Katsunori Furuya[1]

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Background and Purpose of the research

Balinese people used various types of plants for offering ceremonies. This ceremonial activity is based on the beliefs of the Balinese Hindu community, namely the philosophy of *Tri Hita Karana* which upholds the harmonization of the three good relations of fellow human beings, environment, and God. The role of plants is very vital because each ceremony, the community uses plant parts from roots, stems, leaves, flowers, and fruit. The plants used for offering ceremony means are known as ritual plants. The role of the Balinese community in maintaining plant diversity can be seen from the variety of types of ritual facilities. This study will reveal the diversity of plant species used in ceremonial facilities such as *Canang Sari*, *Kwangen*, *Segehan*, *Daksina*, *Pejati*, *Peras*, *Ajuman*, *Sesayut*, and *Penjor*. The existence of ancient ritual plants is effortless to find in the natural environment of Bali. However, the rapid development of tourism led to the conversion of land from agriculture into a built-in space, enabling the loss of the diversity of ritual plant species. Changes in the components of ritual means can occur due to the loss of ritual diversity. Educating the community regarding the importance of the existence of ritual plants is essential to maintain and preserve ritual plants so that in the future Balinese people, especially those living in urban areas, can re-coexist with ritual plants. This study aims to identify plants found in ritual ceremonies, analyzing plant species potentially used in landscape design, and arranging the landscape plan of the riverside in Denpasar by utilizing selected plant species.

Method

Literary studies were carried out to identify the types of plants contained in each ceremonial facility. Descriptive and quantitative analysis of plant species was carried out to determine the value of these plants both functionally and aesthetically. In preparing a landscape plan, a case study was carried out at the border of the *Tukad Mati* River in Denpasar City. The research steps taken are inventory, analysis, synthesis, and planning.

Results

The results of this study revealed that there were 16 plant species in *Canang Sari*, 13 plant species in *Kwangen*, 18 plant species in *Segehan*, 30 plant species in *Daksina*, 43 plant species in *Pejati*, 15 plant species in *Peras*, 23 plant species in *Ajuman*, 21 species plants in *Sesayut*, and 16 plant species at *Penjor* . Several species such as coconut, areca nut, betel and banana are used in 9 types of ritual facilities. Potential plants in landscape design number 25 species, 9 of which fulfill conservation functions, ten species accomplish aesthetic services, and six species perform architectural roles. The green governance plan in the case study carried out at the border of the Tukad Mati River in addition to maintaining existing plants also utilizes potential ritual plant species. The concept of a green governance plan refers to the function of protecting riverside areas, recreational purposes, and public education functions related to the existence of ritual plants.

Conclusion

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The diversity of plants has been identified from 9 types of ceremonial facilities of the Balinese Hindu community. *Pejati* ceremony facilities have the highest plant diversity is 43 species of plants and the Kwangen ceremony facilities have the lowest diversity of plants, namely 13 plant species. 25 plant species have the potential to be used as landscape plants. This plant is recommended for riverside landscape planning in Denpasar city. The concept of green governance refers to the function of protecting river areas, recreational functions, and public education functions.

Keywords: ritual plants, plants diversity, bali, landscape plants, green space, riverbank

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[E] Poster | H (Human Geosciences)：H-SC Social Earth Sciences & Civil/Urban System Sciences

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_17

[H-SC06] Role of Geosciences for sustainable use of marine and coastal ecosystems in urbanized world.

convener:Kalpana Chaudhari(Institute For Sustainable Development and Research)

As per the United Nations estimates, the world population reached 7.3 billion as of mid-2015, implying that world has added approximately one billion people in the span of the last 12 years. The total population on earth is predicted to increase by more than one billion people within the next 15 years, reaching 8.5 billion in 2030, and to increase further to 9.7 billion in 2050 and 11.2 billion by 2100. Urban planning and management plays an important role in achieving the social sustainability through geosciences, environmental sustainability for urban transformation. Over the next generation of greatest increase in population, in production and in poverty will occur in cities in Asia and Africa. Due to this rapid urbanization and industrialization, the problems of urban organizational management, which often linked with geosciences and other socio-political aspects include, management of different urban planning and management, disaster management and resources mobilization, coastal zone management etc. for sustainable urban development will need better understanding of geosciences and linked with societal issues .Therefore it would be necessary to study the urban policies for sustainable development in Developed countries in Europe, Asia-Pacific and its impacts on the public life and also on the social-economic development of the urban region through systematic study of geosciences. This joint session will open up the opportunity for the researchers, scientists and students from AGU, EGU and AOGS to present their research/case studies on this topic and to network for future joint research programs. The joint session focuses on policy formulation for resources planning, coastal risk and vulnerability, social-ecological vulnerability and disaster resilience in coastal communities, Human Pressures on Coastal Environments, land water-seawater interactions for sustaining urban development in Asia-Pacific, Europe, South America and Africa region.

[HSC06-P01] Research on Diffusion Method of Factor in Urban Land Classification

★Invited Papers

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[HSC06-P02] Assessment of facilities for green tourism in Japan: Fifty-six indices in eight regions using online data

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*Jun Zhou[1]

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The reliability analytical results were not satisfactory, and the reason might be that the alpha reliability test was not appropriate for binary data. The binary variable and descriptive analyses were performed to assess the data.

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First, it seemed that nature conservation was a necessary condition for green tourism because the mean of this variable was 0.88. The data indicated that green tourism in Japan was mainly about the development of nature, and protecting cultural heritage was a less frequent response. Second, most of the areas had perfect and diverse methods of transit, including bicycles, cable cars, boats, walkways, and tourist buses. Although Japan has many mountains and seas, there were just a few cable cars and boats. The tourist attractions were easily reached by walking to them. We concluded that, when Japan developed green tourism, it first considered people's needs and convenience. In addition, most areas were government-managed, although a large proportion was privately administered. Last, the mean amount of tourism for the winter season was low (0.71), which was the lowest mean among the seasons. Apparently, although there are holidays in the winter, green tourist attractions open during the winter is less attractive. (**Table 1.** Descriptive statistics)

Conclusion

In sum, the scores were summarized by region. The highest score computed by the binary variable method was in the Chuba region, and the lowest score was in the Shikoku region. The Kansai cultural center and the Kanto economic center were not major areas of green tourism. If we have an opportunity to conduct in-depth research to explore this phenomenon, our findings might benefit the development of green tourism in Japan. (**Figure 1**. Total scores by region)

Keywords: Green tourism, assessment, binary variable, Japan

Table 1. Descriptive statistics

Descriptive Statistics														
	Nature Protection	Bicycle	Pedestrain	Cable car/ Rope way(Mountain)	Tourism bus/ Train	Water transport	Spring	Summer	Autumn	Winter	Official	Private	Natural	Cultural (Heritage)
Valid	56	56	56	56	56	56	55	56	56	56	56	56	56	56
Missing	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Mean	0.8750	0.5179	0.9643	0.1607	0.6071	0.3750	0.9091	0.9286	0.8929	0.7143	0.8750	0.5536	0.9286	0.6786
Std. Deviation	0.3337	0.5042	0.1873	0.3706	0.4928	0.4885	0.2901	0.2599	0.3121	0.4558	0.3337	0.5016	0.2599	0.4713

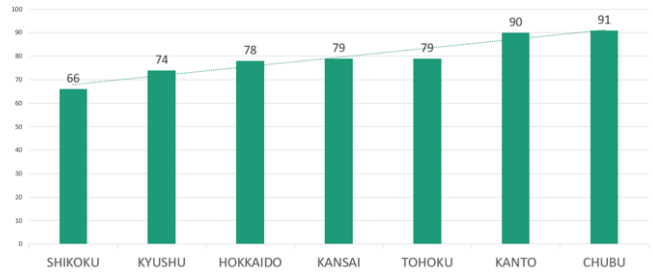

Figure 1. Total scores by region.(The full score is 112 points.)

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Study on Green Tourism Experience ——Cases of Popular Strawberry Farms in Chiba Prefecture

*Yilin Wu[1], Mengying Gao[1], Kazuhei Sato[1], Tingyu Lu[1], Fumeng Zhang[1], Siqi Xing[1], Karolina Brandt[1], Mai Uemura, Katsunori Furuya[1]

1. Graduate School of Horticulture, Chiba University

Background and Objectives

The notion of ‘green tourism’, in which people are encouraged to pursue rural leisure activities in a manner that will benefit the countryside, rather than harm, is gaining popularity. (A. Jones, 1987)

Due to today’s enormous social pressure, many people need proximity to nature in order to get recreation in their leisure time. To promote green tourism in cooperation and participation, MAFF (Ministry of Agriculture, Forestry and Fisheries, Japan) arranges green tourism experiences into five categories; farmer restaurants (to taste), local products shops (to buy), farmhouses (to stay), experience of agriculture, forestry and fisheries (to enjoy) and citizen farms (to make). (MAFF HP,2018)

Chiba prefecture is having an advantage in the location as it adjoins to Tokyo metropolitan area, this means that agriculture, fishery experiences and other wide ranges of green-blue tourism activities that can be done on a one-day-trip from the big city. Therefore, it is convenient for urban residents, travelers and visitors to interact and communicate with local farmers and valuable knowledge and experience can easily be exchanged.

Method

The research was conducted in two stages; by collecting literature information and by analysis. Chiba-ken has been chosen as the study area because of the rich nature and beautiful seascape from three sides surrounded. We chose strawberry farms for research because in recent years strawberry picking has received more and more attention and formed a new trend.

Results and Considerations

According to statistics, it is concluded that the largest agricultural experience project in Chiba prefecture is the strawberry picking (Table). The area with the largest distribution of strawberry farms is Kimitsu area, and especially Kimitsu city (Fig.1). Through the study, we found the main reasons for the prosperity of strawberry picking agriculture in this specific area. First, Kimitsu city as a historic strawberry production area has superior geographical conditions. It is possible for the visitors to do the sightseeing in a one-day-trip as the ride is about one hour from Tokyo or Kanagawa when using the Tokyo Bay Aquarain/Tsuchiyama Auto Roadway (Fig.2). Another crucial reason is the strong support from the agricultural office on the improvement of cultivation technology and management improvement of producers. Producers in Kimitsu city are working diligently and making efforts by participating in a

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workshop held by ‘JA Kimito Strawberry Committee’.

As a kind of agricultural management, sightseeing farms are often used as a sideline by farmers. Therefore, facilities and services are often inadequate from a tourism perspective. Sightseeing agriculture in Kimitsu city has benefited from the direct sales system of strawberries, and it can be said to be a model in sightseeing agriculture. For the consideration of development within tourism agriculture, more regional characteristics should be combined, and more emphasis should be placed on promoting regional advantages.

Keywords: green tourism, agriculture, tourism agriculture, MAFF

Table over the quantity of experiences in Chiba Prefecture

Activities	Strawberry	Sweet Potato	Bamboo Shoot	Rice	Blueberry
Amount	60	32	27	24	22
Activities	Peanut	Pear	Livestock	Flower Picked	Cauliflower
Amount	20	20	18	16	14
Activities	Corn	Potato	Grapes	Soybeans	Chestnut
Amount	13	13	12	12	12
Activities	Char-grilled	Fishery	Nature	Dairy Farm	Aquatic Food
Amount	11	11	10	9	9
Activities	Orange	Wild Vegetable	Broad Bean	Beach Comb	Shiitake
Amount	9	8	6	6	5
Activities	Loquat	Tomato	Persimmon	Fig	Apple
Amount	5	4	4	4	3
Activities	Taro	Kiwi Fruit	Melon	Carrot	Radish
Amount	3	3	3	3	2
Activities	Broccoli	Onion			
Amount	2	2			

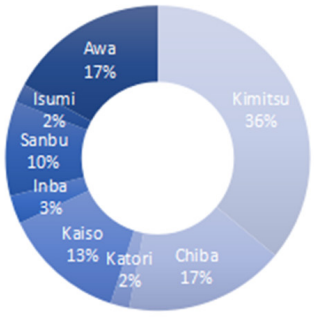

Fig.1 The distribution of strawberry fields

Fig.2 The location of Kimitsu City

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Ritual plant utilization in landscapes planning. Case study: Riverside in Denpasar City.

*I Made Pradnyan Natawiguna[1], Katsunori Furuya[1]

1. Graduate School of Horticulture, Chiba University

Background and Purpose of the research

Balinese people used various types of plants for offering ceremonies. This ceremonial activity is based on the beliefs of the Balinese Hindu community, namely the philosophy of *Tri Hita Karana* which upholds the harmonization of the three good relations of fellow human beings, environment, and God. The role of plants is very vital because each ceremony, the community uses plant parts from roots, stems, leaves, flowers, and fruit. The plants used for offering ceremony means are known as ritual plants. The role of the Balinese community in maintaining plant diversity can be seen from the variety of types of ritual facilities. This study will reveal the diversity of plant species used in ceremonial facilities such as *Canang Sari*, *Kwangen*, *Segehan*, *Daksina*, *Pejati*, *Peras*, *Ajuman*, *Sesayut*, and *Penjor*. The existence of ancient ritual plants is effortless to find in the natural environment of Bali. However, the rapid development of tourism led to the conversion of land from agriculture into a built-in space, enabling the loss of the diversity of ritual plant species. Changes in the components of ritual means can occur due to the loss of ritual diversity. Educating the community regarding the importance of the existence of ritual plants is essential to maintain and preserve ritual plants so that in the future Balinese people, especially those living in urban areas, can re-coexist with ritual plants. This study aims to identify plants found in ritual ceremonies, analyzing plant species potentially used in landscape design, and arranging the landscape plan of the riverside in Denpasar by utilizing selected plant species.

Method

Literary studies were carried out to identify the types of plants contained in each ceremonial facility. Descriptive and quantitative analysis of plant species was carried out to determine the value of these plants both functionally and aesthetically. In preparing a landscape plan, a case study was carried out at the border of the *Tukad Mati* River in Denpasar City. The research steps taken are inventory, analysis, synthesis, and planning.

Results

The results of this study revealed that there were 16 plant species in *Canang Sari*, 13 plant species in *Kwangen*, 18 plant species in *Segehan*, 30 plant species in *Daksina*, 43 plant species in *Pejati*, 15 plant species in *Peras*, 23 plant species in *Ajuman*, 21 species plants in *Sesayut*, and 16 plant species at *Penjor* . Several species such as coconut, areca nut, betel and banana are used in 9 types of ritual facilities. Potential plants in landscape design number 25 species, 9 of which fulfill conservation functions, ten species accomplish aesthetic services, and six species perform architectural roles. The green governance plan in the case study carried out at the border of the Tukad Mati River in addition to maintaining existing plants also utilizes potential ritual plant species. The concept of a green governance plan refers to the function of protecting riverside areas, recreational purposes, and public education functions related to the existence of ritual plants.

Conclusion

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The diversity of plants has been identified from 9 types of ceremonial facilities of the Balinese Hindu community. *Pejati* ceremony facilities have the highest plant diversity is 43 species of plants and the Kwangen ceremony facilities have the lowest diversity of plants, namely 13 plant species. 25 plant species have the potential to be used as landscape plants. This plant is recommended for riverside landscape planning in Denpasar city. The concept of green governance refers to the function of protecting river areas, recreational functions, and public education functions.

Keywords: ritual plants, plants diversity, bali, landscape plants, green space, riverbank

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[E] Oral | H (Human Geosciences)：H-TT Technology & Techniques

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 106 1F

[H-TT20] Environmental Remote Sensing

convener:Wei Yang(Chiba University), Akihiko Kondoh(Center for Environmental Remote Sensing, Chiba University), Chairperson:Wei Yang(Chiba University)

Our human beings are encountering various environmental issues on the Earth, and it is urgent to find out the solutions. Remote sensing is currently the only feasible means to observe the Earth environment at regional/continental /global scales over long periods, and consequently detects the environmental changes occurred all over the world. This session invites presentations on theory, science, technology, and applications of remote sensing to study the Earth environment from regional to global scales. Both oral and poster presentations are sincerely welcome.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[HTT20-01] Evaluation of Climate Change Impacts on Wetland Vegetation in the Dunhuang Yangguan National Nature Reserve in Northwest China Using Landsat Derived NDVI

*Feifei Pan[1] (1.University of North Texas)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[HTT20-02] Characterizing the structure of the boundary layer under heavy pollution over urban area, Beijing, China

*LINLIN WANG[1] (1. Institute of Atmospheric Physics, Chinese Academy of Sciences)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[HTT20-03] **THE STUDY OF RIVER CHANGE DETECTION INTEGRATING OBJECT-BASED CLASSIFICATION AND EDGE EXTRACTION**

*Yu-Chan Lee[1], Fang-Shii Ning[1], Hao-Che Ho[2] (1.Department of Land Economics, National Chengchi University, 2.Department of Civil Engineering, National Taiwan University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[HTT20-04] **Monitoring winter wheat spring phenology in the North China Plain using MODIS**

*Xifang Wu[1], Wei Yang[2], Chunyang Wang[3], Yuki Sofue[4], Yanjun Shen[5], Akihiko Kondoh[2] (1.Graduate School of Science and Engineering , Chiba University, 2.Center for Environmental Remote Sensing, Chiba University, 3.School of Surveying and Land Information Engineering, Henan Polytechnic University, 4.Graduate School of Science, Chiba University, 5.Key Laboratory of Agricultural Water Resources, Center for Agricultural Resources Research, Institute of Genetics and Developmental Biology, Chinese Academy of Sciences)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[HTT20-05] Assessment of numerous Data Assimilation Approaches in Regional Retrieval of Ground NO_2 Spatial Distribution via Remote Sensing products

*Hugo Wai Leung MAK[1,2], Jimmy Chi-Hung FUNG[1,2] (1.Department of Mathematics, Hong Kong University of Science and Technology, 2.Division of Environment and Sustainability, Hong Kong University of Science and Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[HTT20-06] Spectro-polarimetric BRF measurement of leaves and model of individual leaf

*Begzsuren Tumendemberel[1], Yukihiro Takahashi[1], Tetsuro Ishida[1], Junichi Kurihara[1], Nobuyasu Naruse[2] (1.Hokkaido University, 2.Shiga University of Medical Science)

Evaluation of Climate Change Impacts on Wetland Vegetation in the Dunhuang Yangguan National Nature Reserve in Northwest China Using Landsat Derived NDVI

*Feifei Pan[1]

1. University of North Texas

Based on 541 Landsat images between 1988 and 2016, the normalized difference vegetation indices (NDVIs) of the wetland vegetation at Xitugou (XTG) and Wowachi (WWC) inside the Dunhuang Yangguan National Nature Reserve (YNNR) in northwest China were calculated for assessing the impacts of climate change on wetland vegetation in the YNNR. It was found that the wetland vegetation at the XTG and WWC had both shown a significant increasing trend in the past 20–30 years and the increase in both the annual mean temperature and annual peak snow depth over the Altun Mountains led to the increase of the wetland vegetation. The influence of the local precipitation on the XTG wetland vegetation was greater than on the WWC wetland vegetation, which demonstrates that in extremely arid regions, the major constraint to the wetland vegetation is the availability of water in soils, which is greatly related to the surface water detention and discharge of groundwater. At both XTG and WWC, the snowmelt from the Altun Mountains is the main contributor to the groundwater discharge, while the local precipitation plays a lesser role in influencing the wetland vegetation at the WWC than at the XTG, because the wetland vegetation grows on a relatively flat terrain at the WWC, while it grows on a stream channel at the XTG.

Keywords: NDVI, Wetland Vegetation, Climate Change, Precipitation, Air Temperature, Snowmelt

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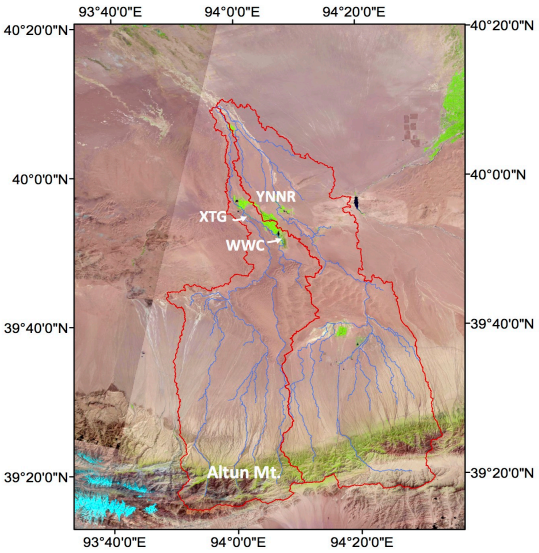

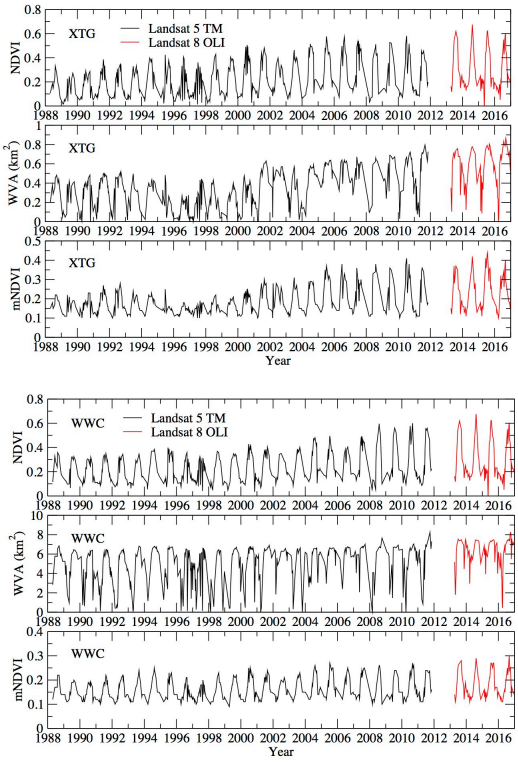

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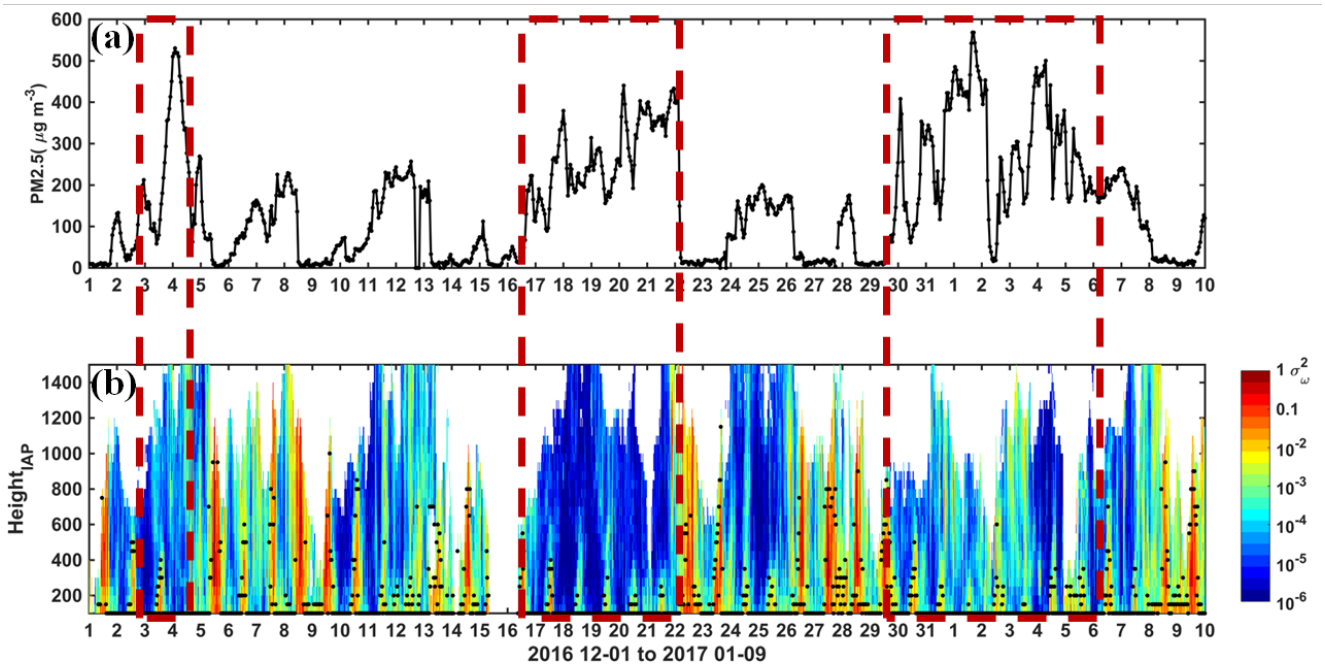
Characterizing the structure of the boundary layer under heavy pollution over urban area, Beijing, China

*LINLIN WANG[1]

1. Institute of Atmospheric Physics, Chinese Academy of Sciences

The boundary layer (BL) structure not only controls the transportation, accumulation and diffusion of primary pollutants but also affects the generation and transformation of secondary aerosols. A better understanding of the interactions between the occurrence of air pollution and the structure of the BL is very important for the air-pollution-relevant investigations. Although the influence of the vertical structure of the BL on air pollution has been recognized in many previous studies, understanding this influence remains limited due to the lack of sufficient field observations, especially for high-temporal-resolution vertical observations. Recently, Lidar techniques have become the most valuable and popular systems to detect the atmosphere because of their higher spatiotemporal resolution. As a result, many techniques have been developed to determine the BL structure by using the remote sensing instruments, such as radar wind profilers, aerosol lidars, and ground-based microwave radiometers. In this study, the BL structure was studied by using a Doppler lidar, a Depolarization lidar and the 325-m meteorological tower in Beijing during the winter 2016-2017, in particular during heavy polluted episodes. The height of BL was estimated by using lidar data. The characteristics of wind, temperature and relative humidity at 15 levels, turbulence transport and radiation balance at three levels (47, 140 and 280 m) were analyzed by using the observational data collected on the 325-m meteorological tower.

Keywords: remote sensing instruments, heavy polluted episodes, Beijing, boudary layer structure



(a) $PM_{2.5}$ at Aoti surface station (red box: heavy polluted episodes);
(b) Velocity variance, σ_w^2 (m^2 s^{-2}), calculated from the Doppler wind lidar data , from 1 December 2016 to 10 January 2017. Derived boundary layer depths, based on the threshold method, are depicted as black dots.

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THE STUDY OF RIVER CHANGE DETECTION INTEGRATING OBJECT-BASED CLASSIFICATION AND EDGE EXTRACTION

*Yu-Chan Lee[1], Fang-Shii Ning[1], Hao-Che Ho[2]

1. Department of Land Economics, National Chengchi University, 2. Department of Civil Engineering, National Taiwan University

Rivers in Taiwan have the characteristics of short mainstream and steep slope. With seasonal changes and different geographic environment, the middle course of drainage basin is prone to lateral erosion and deposition. However, due to the global climate change and the occurrence of natural disasters, the increasing precipitation strength and unstable river channel make the river migration more frequent and complex. Therefore, river governance has become a challenge in recent years.
In the history of change detection, we often needed multi-temporal of remote sensing images. Depending on geographical landscape and types of data, different methods like image classification are applied for change detection. All of these methods have their own advantages and disadvantages, so it is necessary to combine these methods to achieve river change detection. This study used remote sensing data and image processing software for object-based classification and also edge extraction as an aid to achieve river change detection.

Keywords: Change Detection, Image Classification, Edge Extraction, Remote Sensing Images

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Monitoring winter wheat spring phenology in the North China Plain using MODIS

*Xifang Wu[1], Wei Yang[2], Chunyang Wang[3], Yuki Sofue[4], Yanjun Shen[5], Akihiko Kondoh[2]

1. Graduate School of Science and Engineering , Chiba University, 2. Center for Environmental Remote Sensing, Chiba University, 3. School of Surveying and Land Information Engineering, Henan Polytechnic University, 4. Graduate School of Science, Chiba University, 5. Key Laboratory of Agricultural Water Resources, Center for Agricultural Resources Research, Institute of Genetics and Developmental Biology, Chinese Academy of Sciences

North China Plain (NCP) is one of the most important granaries in China. Crop spring phenology is a sensitive indicator of climate change and crop management. Monitoring of crop spring phenology is of great importance to food security. Winter wheat is the main crop cultivated in the study area. There are few studies that evaluate the performance of different vegetation indices in detecting winter wheat spring phenology in the study area. Moreover, the spatiotemporal variation of winter wheat spring phenology since 2000 is also not very clear. In this study, NDVI, EVI and NDPI derived from MODIS were used to investigate the characteristic of winter wheat spring phenology. The results showed that there was good agreement between the winter wheat spring phenology of satellite-based and the ground observation records. At the spatial scale, winter wheat spring phenology derived from NDVI, EVI and NDPI showed the similar spatial pattern. At the regional scale, winter wheat spring phenology monitored by NDVI, EVI and NDPI all showed a delayed trend during 2001-2017. Furthermore, winter wheat spring phenology was most affected by the average temperature from February to mid-March and the cumulative precipitation from November to mid-March. Winter wheat spring phenology was negatively correlated with temperature and precipitation, and the effect of temperature on winter wheat spring phenology was greater than precipitation. The decrease of the average temperature from February to mid-March and cumulative precipitation from November to mid-March were the main reasons for the delayed trend of winter wheat spring phenology during 2001-2017. In addition, the interannual variation of winter wheat spring phenology in the study area was not only affected by climate factors but also influenced by topography and available water resources.

Keywords: Winter wheat, Spring phenology, North China Plain, Temperature, Precipitation, MODIS

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Assessment of numerous Data Assimilation Approaches in Regional Retrieval of Ground NO_2 Spatial Distribution via Remote Sensing products

*Hugo Wai Leung MAK[1,2], Jimmy Chi-Hung FUNG[1,2]

1. Department of Mathematics, Hong Kong University of Science and Technology, 2. Division of Environment and Sustainability, Hong Kong University of Science and Technology

Combating with environmental pollution problems and reducing human exposure to unhealthy levels of airborne chemicals are important global missions nowadays, particularly in more developed cities in China. Existing monitoring network for ground pollutant measurements in most places of southern China are currently too sparse, therefore spatial variation and characteristics in rural regions or places with mixed land use may not be well detected and distinguished. Thus, the use of satellite remote sensing techniques play important roles in observing temporal changes of pollutants within troposphere through satellite scans. Based on tropospheric NO_2 column density inferred from Ozone Monitoring Instrument (OMI), together with certain meteorological quantities, ground NO_2 spatial distribution could be retrieved via data assimilation techniques, thus providing a possibility to detect changes of pollutants within a prescribed domain over long period.

In this research, we adopt the use of modified Berkeley High Resolution product (BEHR-HK v3.0C) and meteorological outputs from the Weather Research and Forecasting (WRF) model to describe tropospheric NO_2 column density within southern China, especially Greater Bay Area. The preliminary steps of such approach are mostly in line with NASA Standard Product, however it makes use of higher-resolution a priori NO_2 profiles and terrain patterns to reformulate the Air Mass Factor (AMF), thus doing a better job in capturing changes of NO_2 within lower troposphere, particularly in places with large spatial variabilities and terrain height differences like China.

Furthermore, based on understanding in atmospheric meteorology, we combine the use of updated tropospheric NO_2 column density and 8 meteorological factors from WRF (e.g. Planetary Boundary Layer Height (PBLH), atmospheric pressure and perturbation potential temperature), then retrieve the estimated spatial distribution of ground-level NO_2 concentration in southern China within 4 seasons of 2015, via combination of machine learning approaches and kernel-based probabilistic models. These data assimilation techniques include non-parametric models like Gaussian Process Regression (GPR), imposing of different statistical kernels (like Gaussian or Radial Basis Function (RBF)) or Support Vector Machine (SVM). Retrieval results are then validated by available measurement datasets obtained from ground monitoring stations. Respective accuracy and applicability of these models are assessed by same statistical metrics, which we conclude that GPR model reaches the best performance in predicting ground NO_2 concentration after a series of machine learning and training processes were applied, followed by Tree Ensemble model. This finding opens new window into long-term ground NO_2 retrieval and prediction, and dealing with environmental problems that require continuous monitoring and assessments.

Keywords: Satellite Remote Sensing Techniques, Tropospheric Column Density and Ground Retrieval, Inverse Approaches in Data Assimilation

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Spectro-polarimetric BRF measurement of leaves and model of individual leaf

*Begzsuren Tumendemberel[1], Yukihiro Takahashi[1], Tetsuro Ishida[1], Junichi Kurihara[1], Nobuyasu Naruse[2]

1. Hokkaido University, 2. Shiga University of Medical Science

The reflectance of the leaf consists not only of its intensity but also of polarization, and the polarization techniques are generally used for separating specular reflectance from diffuse reflectance. The internal diffuse component of the spectral reflectance contains the details of the biochemical properties of the plant, an activity of photosynthesis, an expected amount of harvest, and water condition. Specular reflectance of the leaf strongly depends on a combination of the angle of incidence of the light source and the angle of observation view. The leaves look shiny at the shallow angle, where most of this reflection is polarized from the surface of leaves. Although the leaf spectral reflectance which is a point of convergence for many types of research, the study of spectral measurement with polarization in a single leaf is largely unexplored. To do this, the estimation of single leaf BRDF of Coffea canephora Pierre (Coffee), Epipremnum aureum (Pothos), and Fragaria ×ananassa (Strawberry) was carried out based on the measurements by Liquid Crystal Tunable Filter (LCTF) camera in the wavelength range of 460-780 nm with a linear polarizer. The imaging with the multispectral LCTF camera has a great advantage in measuring a selected leaf area with an arbitrary size of the field of view. There are hundreds of combinations of incident light and observation direction in single leaf Bidirectional Reflectance Factor (BRF) measurement. In order to conduct the measurements for all those conditions, we built the automatic goniometer with LCTF camera in a laboratory.
In previous studies, the leaf BRF prediction is usually based on the Cook-Torrance (Cook and Torrance, 1981) prevalent model in computer graphics assuming that the surface micro-geometry acts as a set of specular mirrors. Another type of models are widely used in the optics community, computing diffraction effects caused by differences in height in the surface micro-geometry and predicts visual appearance from the frequency content of the height distribution. The Cook-Torrance model may not be suitable for the leaf reflectance in our observation because the actual measurement cannot determine the surface roughness. The Generalized Harvey-Shack (GHS) scattering theory is well studied from rebound models determined by height distribution (Krywonos, 2006) and the GHS theory is not limited to any special wavelength range and RMS roughness value. Spectro-polarimetric measurement results and physical scattering theory have led us to create a new reflectance model. We successfully created a new leaf bidirectional reflectance model which considers that the diffuse component is Lambertian inside of the leaves and an internal scattering coefficient is calculated to an output value of PROSPECT model; the specular component is explained by GHS scattering theory. The polarization property of reflected light on a single leaf is also identified and rebuild bidirectional reflectance factors including polarized, unpolarized, and the total reflectance factors according to our model in this work. Finally, a new spectro-polarimetric bidirectional method is more controllable for the BRF pattern of a single leaf.

Keywords: BRDF measurement , Polarization, leaves , spectral

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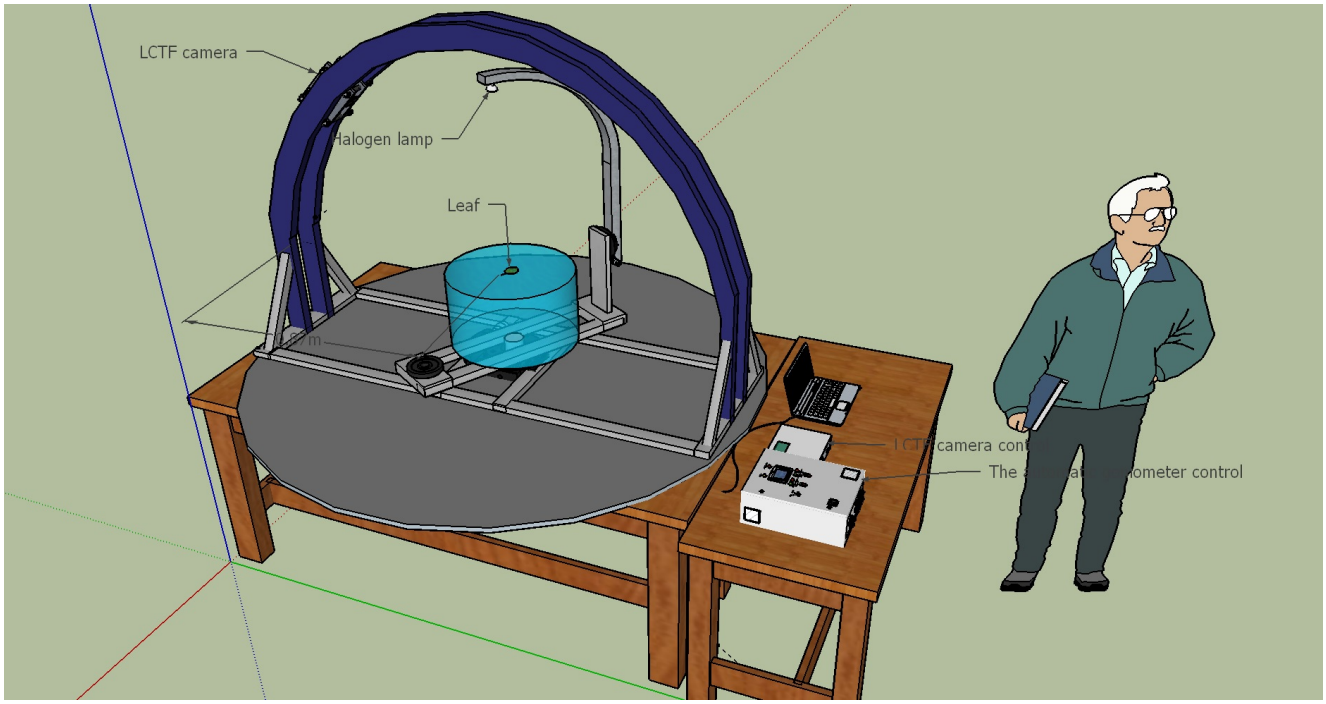

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[E] Poster | H (Human Geosciences)：H-TT Technology & Techniques

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_11

[H-TT20] Environmental Remote Sensing

convener:Wei Yang(Chiba University), Akihiko Kondoh(Center for Environmental Remote Sensing, Chiba University)

Our human beings are encountering various environmental issues on the Earth, and it is urgent to find out the solutions. Remote sensing is currently the only feasible means to observe the Earth environment at regional/continental /global scales over long periods, and consequently detects the environmental changes occurred all over the world. This session invites presentations on theory, science, technology, and applications of remote sensing to study the Earth environment from regional to global scales. Both oral and poster presentations are sincerely welcome.

[HTT20-P01] Classification of Winter Wheat using high spatial resolution data in North China Plain

*Chunyang Wang[1,2], Wei Yang[2], Xifang Wu[3], Zhichao Chen[1], Junjun Lu[1], Zongze Zhao[1], Hebing Zhang[1] (1.School of Surveying and Land Information Engineering, Henan Polytechnic University, 2.Center for Environmental Remote Sensing, Chiba University, 3.Graduate School of Science and Engineering, Chiba University)

[HTT20-P02] Normalized Difference Greenness Index (NDGI): A new vegetation index for improved estimation of vegetation phenology

*Wei Yang[1], Hideki Kobayashi[2], Akihiko Kondoh[1] (1.Chiba University, 2.JAMSTEC)

[HTT20-P03] *Characteristics of manual and automatically tree species classification in mixed forest (Yamagata University Research Forest)*

*Sarah Kentsch[1,2], Larry Maximo Lopez Caceres[1], Yago Diez[1], Motohisa Fukuda[1] (1.Yamagata University, 2.United Graduate School of Agricultural Sciences)

[HTT20-P04] Land subsidence detection by SBAS-InSAR technology and its factor analysis in the inland area of Chiba Prefecture

*HALIPU AYIHUMAIER[1], Richa Bhattarai[1], Wen - LIU[1], Akihiko - Kondoh[1,2] (1.Graduate School of Science and Engineering, 2.Center for Environmental Remote Sensing, Chiba University)

[HTT20-P05] Development of a novel data fusion model to generate high spatiotemporal resolution NDVI time series

*Wei Yang[1], Jin Chen[2] (1.Chiba University, 2.Beijing Normal University)

Classification of Winter Wheat using high spatial resolution data in North China Plain

*Chunyang Wang[1,2], Wei Yang[2], Xifang Wu[3], Zhichao Chen[1], Junjun Lu[1], Zongze Zhao[1], Hebing Zhang[1]

1. School of Surveying and Land Information Engineering, Henan Polytechnic University, 2. Center for Environmental Remote Sensing, Chiba University, 3. Graduate School of Science and Engineering, Chiba University

Winter Wheat in North China Plain (NCP) is one of the key food sources for securing food safety of China. Mapping the spatial distributions of winter wheat plays crucial roles in monitoring of planting areas and estimation of winter wheat production, which is usually carried out through classification of satellite images. The traditional classification methods are mainly based on data collection, download storage, and local analysis. However, these approaches are not capable of dealing with the quick mapping of massive satellite data including high spatial-temporal resolutions over large-scale areas. To overcome this challenge, this study developed a processing chain for mapping winter wheat of NCP at 10 m resolution using Sentinel-2-based NDVI time series on the google earth engine (GEE) platform, a cloud computing platform for Earth science data and analysis. First, the influence of phenology between the north and the south of the NCP on classification is eliminated by using the locally selected training data sets. Second, the data contaminated by clouds were all removed. Third, the training sample sets are constructed, and the typical features are searched. Last, two machine learning algorithms were applied to yield the classification result map, that is, Random Forest (RF) method and Regression Trees (CART) method. Validation results showed that the final maps and classification accuracy of RF method was better than SVM and CART method, with total accuracy of 81%. Moreover, this study also demonstrated that the GEE platform can yield dramatically higher efficiency than conventional classification methods by reducing downloading time and local storage capacity. Consequently, we recommend that the GEE cloud computing platform is a more suitable research tool for large-scale geospatial analysis and application.

Keywords: Google earth engine, Cloud computing, Big data, Classification, Sentinel-2, Winter wheat

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Normalized Difference Greenness Index (NDGI): A new vegetation index for improved estimation of vegetation phenology

*Wei Yang[1], Hideki Kobayashi[2], Akihiko Kondoh[1]

1. Chiba University, 2. JAMSTEC

Satellite monitoring of vegetation phenology is crucial to understanding the biological impacts of climate change. Nevertheless, satellite-based phenology estimation can be biased by effects of snow using conventional vegetation indices (VIs), such as the normalized difference vegetation index (NDVI). To eliminate effects of snow, snow-free VIs that take advantage of the shortwave infrared (SWIR) band have been proposed (i.e., phenology index [PI] and normalized difference phenology index [NDPI]). However, PI cannot properly capture the presence of sparse vegetation, and NDPI does not account for the influence of dry vegetation. Here, we propose a novel snow-free VI, designated the normalized difference greenness index (NDGI), using reflectance of green, red, and near-infrared (NIR) bands. NDGI is a semi-analytical index deduced based on the linear spectral mixture model and the spectral characteristics of vegetation, snow, soil, and dry grass. Its performance for estimating the start of growing season (SOS) and end of growing season (EOS) was evaluated using simulation datasets, time-lapse camera data of tundra sites, and flux tower gross primary production (GPP) data of grassland sites. Simulation results demonstrated that NDGI can exclude the influence of snow on SOS and EOS estimations. In the camera sites, NDGI markedly outperformed NDVI, PI, and NDPI for SOS estimation with RMSE=6.46 days and Bias=-1.32 days (vs. RMSE range 12.39–14.8 days and Bias>3.5 days for the other VIs), and for EOS estimation with RMSE=8.33 days and Bias=0.11 days (vs. RMSE range 8.00–26.74 days and Bias>2.67 days for the other VIs). In the GPP sites, NDGI also outperformed the other VIs for SOS estimation with RMSE=10.32 days and Bias=-4.91 days (vs. RMSE range 12.9–24.74 days and Bias>6.13 days for the other VIs). Although its performance was lower for monitoring EOS than SOS in GPP sites, it still outperformed the other VIs in EOS estimation. These results indicate the potential of NDGI for operational monitoring of plant phenology in the tundra and grassland ecosystems based on satellite observations.

Keywords: plant phenology, remote sensing, snow, MODIS

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Characteristics of manual and automatically tree species classification in mixed forest (Yamagata University Research Forest)

*Sarah Kentsch[1,2], Larry Maximo Lopez Caceres[1], Yago Diez[1], Motohisa Fukuda[1]

1. Yamagata University, 2. United Graduate School of Agricultural Sciences

A low degree of knowledge combined with a complex structure of mixed forests is the reason why researchers still investigate in mixed forest research for getting a deeper understanding. Especially mixed forests in Japan are influenced by the characteristically relief and the climate conditions. There is a high demand on accurate information about tree species of mixed forests. This high demand requires accurate investigation possibilities included by an easier access to the needed information' s (Fritz, 2013). Methods to get accurate information on a large scale with easy access to the desired information are needed. Previous studies show the applicability of drones for forest applications (Torresan et. al, 2016). Images taken with a drone offer new methods to get information of forests like distribution, health condition or automatically classifications of tree species. For example, Onishi & Ise (2018) reached accuracies of up to 90 %. But these studies also illustrated that there are limitations and gaps in knowledge for the applicability of using UAV. Especially, a lot of those high accuracies were reached in forest plantations. There is a need of more detailed information about how to get more accurate information in real forests by using drones (Michez et al., 2016).

The Yamagata Research Forest offers the opportunity to study mixed forests with different conditions in different parts of the forest for doing automatically classifications of tree species. Till now two study sites were defined and image were taken with a camera detecting the visual spectrum of the light. Also, images were taken during different seasons (summer and autumn). After taking the images they needed to be processed. A first step is to generate orthomosaics by merging the images using Photoscan from Agisoft. As a result, DEMs, orthomosaics and 3D models were generated and can be further analyzed. In the next step the segmentation and classification of tree species should be done in an object-based way using feature information of the trees. After processing the images, it should be possible to create a model for deep machine learning which will be able to do the classification on its own.

During the last year the first image taking took place in different seasons in the Yamagata University Research Forest. Also, the image processing with Photoscan was finished. The first images were analyzed manually to check how it is possible to separate tree species automatically. To find out what are the important factors for doing automatically classification is the actual research status. Further, the presentation handles the comparison of manually and automatically ways for doing separations in this research. The results will be first approaches to do automatically classification/separations of tree species.

Literature:

Fritz, A.; Kattenborn, T.; Koch, B., 2013: UAV-based photogrammetric point clouds –tree stem mapping in open stands in comparison to terrestrial laser scanner point clouds; International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Volume XL-1/W2.

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Torresan, C. et. al, 2016: Forestry applications of UAVs in Europe: A review, International journal of remote sensing, https://doi.org/10.1080/01431161.2016.1252477

Keywords: tree species classification, UAV, Yamagata Research Forest, Image processing, Photoscan

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Land subsidence detection by SBAS-InSAR technology and its factor analysis in the inland area of Chiba Prefecture

*AYIHUMAIER HALIPU[1], Richa Bhattarai[1], Wen - LIU[1], Akihiko - Kondoh[1,2]

1. Graduate School of Science and Engineering, 2. Center for Environmental Remote Sensing, Chiba University

Land subsidence seriously influences the safety of our property. There have been many studies on the deformation of the ground surface due to the groundwater or natural gas extraction. Recently, a large amount of land subsidence had occurred in the Quaternary upland areas in the inland areas of Chiba Prefecture, Japan. There is less evidence of big wells of groundwater or natural gas, and the mechanism of subsidence is not yet clear. So far, SBAS-InSAR (Small Baseline Subset algorithm -Interferometric Synthetic Aperture Radar) technology had been used in the investigation process to clarify the phenomenon of land subsidence in some inland areas of Chiba Prefecture. The ALOS-PALSAR and ALOS-2 PALSAR-2 data for 2006-2010 and 2014-2018 were collected, respectively. The maps of the land subsidence phenomena in Yachimata-Tomisato area are created, and the maps reveal the spatial and temporal distribution of upland area land subsidence. The extent of the subsidence zone are almost consistent with the land survey results. Next step is to reveal the mechanism of land subsidence. At the JpGU2019, we will make a discussion on the possibility of decline of fluid pressure in deep layer.

Keywords: SBAS-InSAR technology, Land subsidence, Chiba Prefecture

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Development of a novel data fusion model to generate high spatiotemporal resolution NDVI time series

*Wei Yang[1], Jin Chen[2]

1. Chiba University, 2. Beijing Normal University

Normalized Difference Vegetation Index (NDVI) is one of the most commonly used vegetation indices for monitoring ecosystem dynamics and modeling biosphere processes. However, global NDVI products are usually provided with relatively coarse spatial resolutions that lack important spatial details. Producing NDVI time-series data with high spatiotemporal resolution is indispensable for monitoring land surfaces and ecosystem changes, especially in spatiotemporally heterogeneous areas. We therefore proposed an Improved Flexible Spatiotemporal DAta Fusion (IFSDAF) method to fill this need. In accord with the distinctive characteristics of NDVIs with large data variance and high spatial autocorrelation compared with raw reflectance bands, the IFSDAF method first produces a time-dependent increment with linear unmixing and a space-dependent increment via thin plate spline interpolation. It then makes a final prediction by optimal integration of these two increments with the constrained least squares method. Moreover, the IFSDAF was developed with the capacity to use all available finer-scaled images, including those partly contaminated by clouds. NDVI images with coarse spatial resolution (MODIS) and fine spatial resolution (Landsat and Sentinel) in areas with great spatial heterogeneity and significant land cover changes were used to test the performance of the IFSDAF method. The root mean square error and relative root mean square error of predicted relative to observed results were 0.0884 and 22.12%, respectively, in 3 heterogeneous areas, and 0.0546 and 25.77%, respectively, in areas of land-cover change. These promising results demonstrated the strength and robustness of the IFSDAF method in providing reliable NDVI datasets with high spatial and temporal resolution to support research on land surface processes. The efficiency of the proposed IFSDAF method can be greatly improved by using only the space-dependent increment. This simplification will make IFSDAF a feasible method for monitoring global vegetation.

Keywords: Spatiotemporal data fusion, High spatial and temporal resolution, Weighted integration

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[E] Poster | H (Human Geosciences)：H-TT Technology & Techniques

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_18

[H-TT20] Environmental Remote Sensing

convener:Wei Yang(Chiba University), Akihiko Kondoh(Center for Environmental Remote Sensing, Chiba University)

Our human beings are encountering various environmental issues on the Earth, and it is urgent to find out the solutions. Remote sensing is currently the only feasible means to observe the Earth environment at regional/continental /global scales over long periods, and consequently detects the environmental changes occurred all over the world. This session invites presentations on theory, science, technology, and applications of remote sensing to study the Earth environment from regional to global scales. Both oral and poster presentations are sincerely welcome.

[HTT20-P01] Classification of Winter Wheat using high spatial resolution data in North China Plain

*Chunyang Wang[1,2], Wei Yang[2], Xifang Wu[3], Zhichao Chen[1], Junjun Lu[1], Zongze Zhao[1], Hebing Zhang[1] (1.School of Surveying and Land Information Engineering, Henan Polytechnic University, 2.Center for Environmental Remote Sensing, Chiba University, 3.Graduate School of Science and Engineering, Chiba University)

[HTT20-P02] Normalized Difference Greenness Index (NDGI): A new vegetation index for improved estimation of vegetation phenology

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[HTT20-P03] *Characteristics of manual and automatically tree species classification in mixed forest (Yamagata University Research Forest)*

*Sarah Kentsch[1,2], Larry Maximo Lopez Caceres[1], Yago Diez[1], Motohisa Fukuda[1] (1.Yamagata University, 2.United Graduate School of Agricultural Sciences)

[HTT20-P04] Land subsidence detection by SBAS-InSAR technology and its factor analysis in the inland area of Chiba Prefecture

*HALIPU AYIHUMAIER[1], Richa Bhattarai[1], Wen - LIU[1], Akihiko - Kondoh[1,2] (1.Graduate School of Science and Engineering, 2.Center for Environmental Remote Sensing, Chiba University)

[HTT20-P05] Development of a novel data fusion model to generate high spatiotemporal resolution NDVI time series

*Wei Yang[1], Jin Chen[2] (1.Chiba University, 2.Beijing Normal University)

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Keywords: Google earth engine, Cloud computing, Big data, Classification, Sentinel-2, Winter wheat

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Keywords: tree species classification, UAV, Yamagata Research Forest, Image processing, Photoscan

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Land subsidence detection by SBAS-InSAR technology and its factor analysis in the inland area of Chiba Prefecture

*AYIHUMAIER HALIPU[1], Richa Bhattarai[1], Wen - LIU[1], Akihiko - Kondoh[1,2]

1. Graduate School of Science and Engineering, 2. Center for Environmental Remote Sensing, Chiba University

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Development of a novel data fusion model to generate high spatiotemporal resolution NDVI time series

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Keywords: Spatiotemporal data fusion, High spatial and temporal resolution, Weighted integration

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[J] Poster | H (Human Geosciences)：H-TT Technology & Techniques

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_12

[H-TT24] Environmental Remote Sensing

convener:Hiroto Shimazaki(National Institute of Technology, Kisarazu College), Akihiko Kondoh(Center for Environmental Remote Sensing, Chiba University), HASEGAWA Hitoshi(Kokushikan University), Teppei Ishiuchi(Miyagi University)

Measuring environmental changes at various spatio-temporal scales is the key to improve our understanding of the relationship between human activities and environmental problems. Remote sensing is a powerful tool to acquire information on the earth's surface frequently and repeatedly over a broad spatial scale, enabling us to find the changes which might be related to the cause and consequence of environmental degradation. This session discusses the applications of remote sensing to the detection and monitoring of environmental changes in time and space, and aims to promote the knowledge-sharing for better management of the environmental problems and natural disaster in any place in the world.

[HTT24-P01] A comparison and practical use of the landcover classification using ALOS/PALSAR and LANDSAT8/OLI

*Keiji Kimura[1] (1.Department of Geography, Nara University)

[HTT24-P02] A possibility of the identification of bottom sediment in shallow-water area using ALOS-3 image from a point of view for the environmental monitoring and protection in coastal areas

*YOSEI MIZUKAMI[1] (1.Japan Aerospace Exploration Agency)

[HTT24-P03] Evaluation of the impact of nomadism and settlement on grassland based on GPS observation data

*Deni Eer[1], Qinxue Wang[1], Tomohiro Okadera[1], Batkhishig Ochirbat[2] (1.National Institute for Environmental Studies, 2.Institute of Geography-Geoecology, Mongolian Academy of Sciences, Mongolia)

A comparison and practical use of the landcover classification using ALOS/PALSAR and LANDSAT8/OLI

*Keiji Kimura[1]

1. Department of Geography, Nara University

In this study, land cover classification was made by the full polarimetry analysis using the L band of ALOS/PALSAR in Asuka Village, Nara, JAPAN. The comparison about the inspection and the precision between a classification by full polarimetry with ALOS/PALSAR and by optical data analysis with LANDSAT8 was held. The field work was the most important method to inspect. As a result, the full polarimetric image was very useful to classify the land cover in all seasons even in deciduous broad-leaved forest. However, the shadow area nor the ponds like mirror surface were not able to be classified because the sensor angle was low and an electric wave did not reach. Crowded houses were recognized to be buildings, but some houses in a sparse residential area was not. In addition, right land cover was able to be distinguished at the place of the gentle topography including the rice field.

Keywords: land cover classification, ALOS/PALSAR, full polarimetry

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A possibility of the identification of bottom sediment in shallow-water area using ALOS-3 image from a point of view for the environmental monitoring and protection in coastal areas

*YOSEI MIZUKAMI[1]

1. Japan Aerospace Exploration Agency

As a successor to the wide swath and high spatial resolution optical mission of the ALOS, which was launched in 2006, the development of ALOS-3 has been underway for the launch in 2020. AlOS-3 has the observation width of 70km(nadir) same as ALOS and the advanced sensor WISH (wide-swath and high-resolution optical imager). The observation performance of WISH is higher than PRISM and AVNIR-2 onboard ALOS, The ground spatial resolutions are 0.8 m (panchromatic) and 3.2 m (multi-color bands), and the number of quantization bits was 8 bits in AlOS, increasing to 11 bits. In particular, AlOS-3 's multi-bands are 6 wavelengths, whereas it was 4 bands of AVNIR-2, in addition to these 4 bands, a total of 6 bands plus 2 bands of Coastal and Red edge. The main purpose of the ALOS-3 mission is to contribute to disaster prevention and mitigation, and the understanding of the damage situation after a disaster occurs and to the development and renewal of high-precision geospatial information. It is also expected to use various observational functions for environmental monitoring of coastal areas and to use and research for environmental conservation in vegetation areas. In this study, we report on the possibility of classification of sediment in shallow sea area using satellite images which are simulated to ALOS-3 observation performance from the viewpoint of conservation of coastal environment. The area of study was a coral reef in the Yaeyama islands of Okinawa Prefecture, including Ishigaki Island, where water quality was relatively stable in coastal shallow waters. The satellite images as ALOS-3 simulation are Digital Globe Worldview (WV), close to AlOS-3 's observation performance. The WV data (ortho-rectified) is used to resize the WISH equivalent to 0.8 m (panchromatic) and 3.2 m (multi-color) for our analysis.The results of the analysis by ALOS/AVNIR-2 near the season of WV’ s observing date/time are also shown as a comparison. In the sediment identification of shallow sea area by satellite remote sensing, the effect of the water depth (tide level) difference is a problem, and a depth correction algorithm has been proposed as one of the methods to reduce the influence. This algorithm is based on the basic principle (Lyzenga, 1978) in which the logarithm of the pixel value (digital number) in the two wavelength bands in the same bottom quality is constant slope not involved in the depth, the index of the bottom quality was removed information of the depth it is intended to calculate.
The results of analysis using Coastal and Red Edge which are the features of ALOS-3 sensor are also reported. Our resuls showed that it can be distinguished more in detail than AVNIR-2(10m) so far. ALOS-3 data is expected to be used as a coastal environmental monitoring tool.

Keywords: ALOS-3, WISH, ALOS, Bottom Index, Coral Reef

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Evaluation of the impact of nomadism and settlement on grassland based on GPS observation data

*Deni Eer[1], Qinxue Wang[1], Tomohiro Okadera[1], Batkhishig Ochirbat[2]

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In grassland ecosystems in Mongolian Plateau, pastoral industry has been implemented since long ago. However, the system of land use differs across national borders, and the management method of pastoralism in the grassland ecosystem of China and Mongolia has greatly changed. In Inner Mongolia Autonomous Region of China, the market economy has progressed since 1978, and the settlement has advanced with the introduction of grassland contracting system in the "grassland law". Meanwhile, in Mongolia, the livestock numbers greatly increased with the introduction of market economy in 1990, and the traditional nomadic system has been greatly changed. Under such conditions, it is necessary for us to evaluate quantitatively the influence of different systems of grassland utilization on grassland productivities. In this study, we use the active sensor and GPS track to monitor both intensity and area of livestock activity as well as its influence on vegetation index of grassland in Inner Mongolia Autonomous Region with the settlement system and Mongolian country with the traditional nomadic system. We selected two sites in each country, and a long-term monitoring for about one year has been done, and high-resolution data with an interval of 20-minute have been collected. In addition, we analyzed the fluctuation of MODIS vegetation index (NDVI) and evaluated the influence of nomadism and settlement on grassland productivity.

The results show that farmers with 1,100 livestock grazing in Mongolia moved in all seasons from spring to winter, so that the range of livestock's activity exceeds about 30 km^2 in one year (Fig.1 (1)).Compared with this, two sites in Inner Mongolia Autonomous Region of the settled farmer grazed 300-400 livestock in the fence range, which was about 1/30 of the nomadic range (Fig.1 (3, 4)). It was showed that the range of activity and the frequency of feeding was greatly different under the different systems of nomadism and settlement (Fig. 1). In settled areas, the annual access frequency around wells was large. In comparison, nomadism camped along the river during the summer, camped along the mountains during the winter, and camped somewhere very shortly in the spring and autumn. Finally, long-term MODIS vegetation index (NDVI) data analysis showed a change in long-term trend of grassland vegetation, suggesting the different effects of nomadism and settlement on grassland productivity.

Keywords: GPS, Nomadism, Settlement

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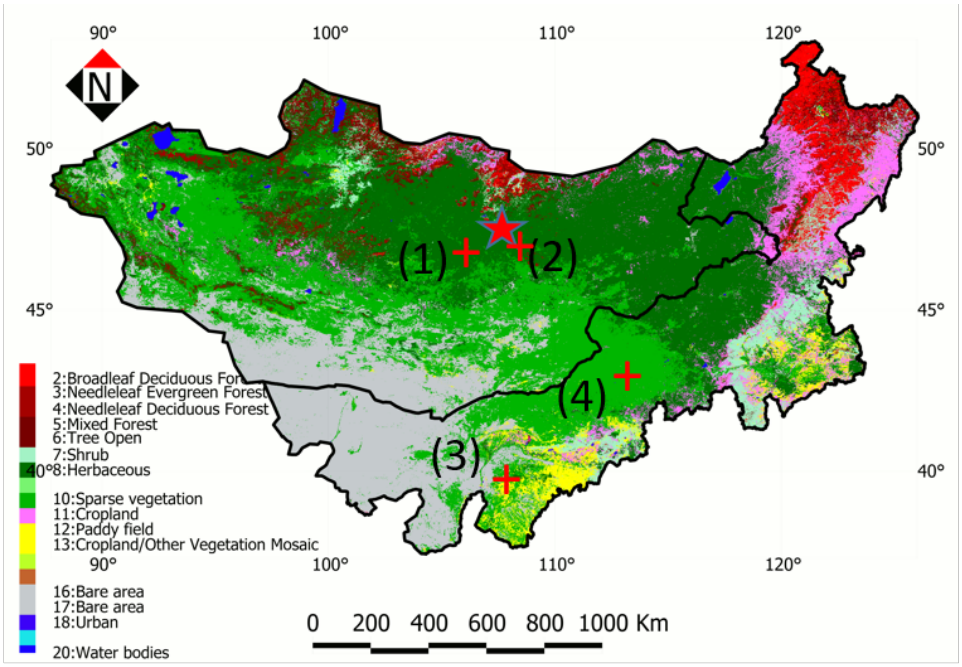

(1): Hustai site (2): Nalaikh site (3): Ordos Site (4): Xilingol site

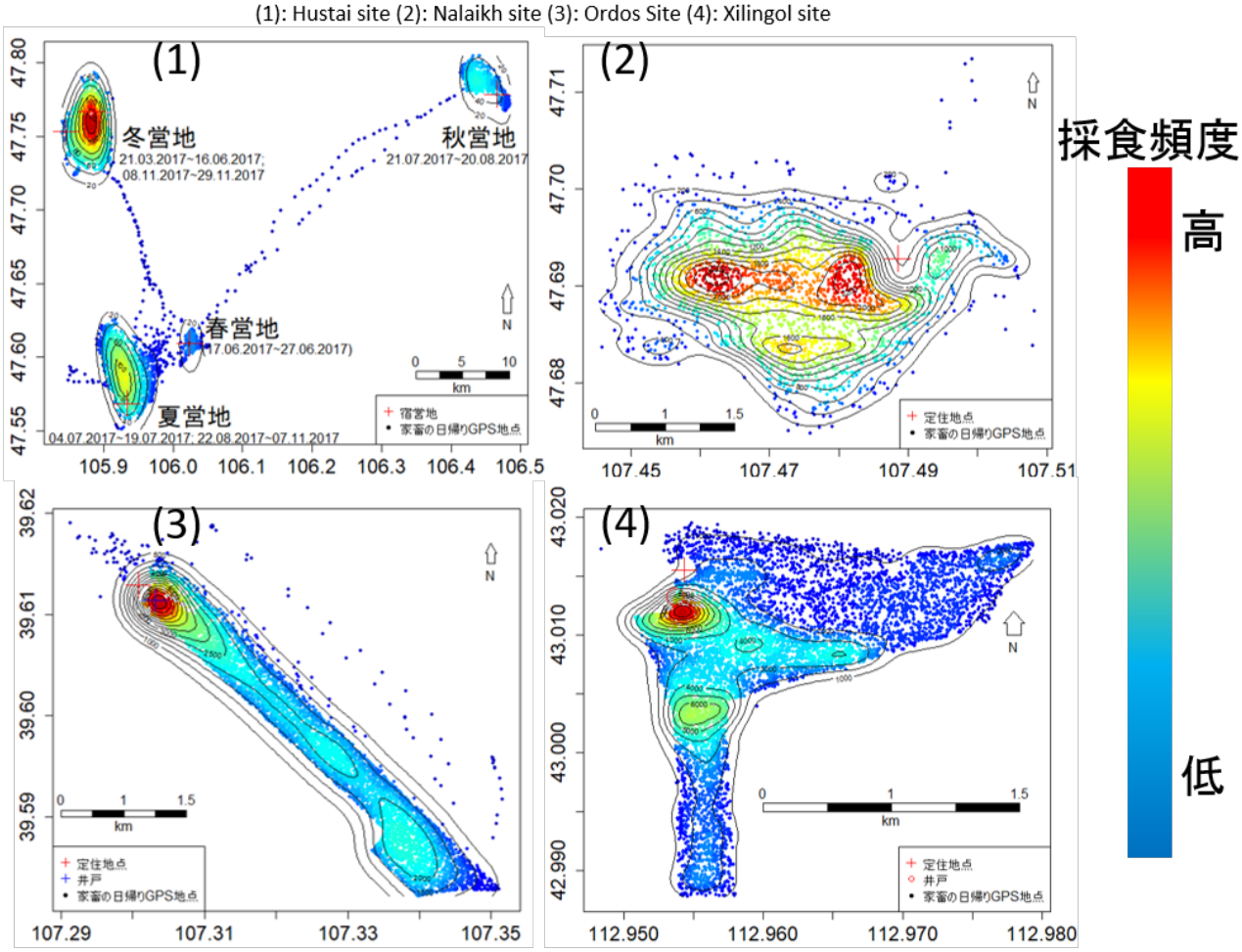

図-1　遊牧と定住化による放牧圧の相違
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[J] Poster | H (Human Geosciences)：H-TT Technology & Techniques

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_19

[H-TT24] Environmental Remote Sensing

convener:Hiroto Shimazaki(National Institute of Technology, Kisarazu College), Akihiko Kondoh(Center for Environmental Remote Sensing, Chiba University), HASEGAWA Hitoshi(Kokushikan University), Teppei Ishiuchi(Miyagi University)

Measuring environmental changes at various spatio-temporal scales is the key to improve our understanding of the relationship between human activities and environmental problems. Remote sensing is a powerful tool to acquire information on the earth's surface frequently and repeatedly over a broad spatial scale, enabling us to find the changes which might be related to the cause and consequence of environmental degradation. This session discusses the applications of remote sensing to the detection and monitoring of environmental changes in time and space, and aims to promote the knowledge-sharing for better management of the environmental problems and natural disaster in any place in the world.

[HTT24-P01] A comparison and practical use of the landcover classification using ALOS/PALSAR and LANDSAT8/OLI

*Keiji Kimura[1] (1.Department of Geography, Nara University)

[HTT24-P02] A possibility of the identification of bottom sediment in shallow-water area using ALOS-3 image from a point of view for the environmental monitoring and protection in coastal areas

*YOSEI MIZUKAMI[1] (1.Japan Aerospace Exploration Agency)

[HTT24-P03] Evaluation of the impact of nomadism and settlement on grassland based on GPS observation data

*Deni Eer[1], Qinxue Wang[1], Tomohiro Okadera[1], Batkhishig Ochirbat[2] (1.National Institute for Environmental Studies, 2.Institute of Geography-Geoecology, Mongolian Academy of Sciences, Mongolia)

A comparison and practical use of the landcover classification using ALOS/PALSAR and LANDSAT8/OLI

*Keiji Kimura[1]

1. Department of Geography, Nara University

In this study, land cover classification was made by the full polarimetry analysis using the L band of ALOS/PALSAR in Asuka Village, Nara, JAPAN. The comparison about the inspection and the precision between a classification by full polarimetry with ALOS/PALSAR and by optical data analysis with LANDSAT8 was held. The field work was the most important method to inspect. As a result, the full polarimetric image was very useful to classify the land cover in all seasons even in deciduous broad-leaved forest. However, the shadow area nor the ponds like mirror surface were not able to be classified because the sensor angle was low and an electric wave did not reach. Crowded houses were recognized to be buildings, but some houses in a sparse residential area was not. In addition, right land cover was able to be distinguished at the place of the gentle topography including the rice field.

Keywords: land cover classification, ALOS/PALSAR, full polarimetry

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A possibility of the identification of bottom sediment in shallow-water area using ALOS-3 image from a point of view for the environmental monitoring and protection in coastal areas

*YOSEI MIZUKAMI[1]

1. Japan Aerospace Exploration Agency

As a successor to the wide swath and high spatial resolution optical mission of the ALOS, which was launched in 2006, the development of ALOS-3 has been underway for the launch in 2020. AlOS-3 has the observation width of 70km(nadir) same as ALOS and the advanced sensor WISH (wide-swath and high-resolution optical imager). The observation performance of WISH is higher than PRISM and AVNIR-2 onboard ALOS, The ground spatial resolutions are 0.8 m (panchromatic) and 3.2 m (multi-color bands), and the number of quantization bits was 8 bits in AlOS, increasing to 11 bits. In particular, AlOS-3 's multi-bands are 6 wavelengths, whereas it was 4 bands of AVNIR-2, in addition to these 4 bands, a total of 6 bands plus 2 bands of Coastal and Red edge. The main purpose of the ALOS-3 mission is to contribute to disaster prevention and mitigation, and the understanding of the damage situation after a disaster occurs and to the development and renewal of high-precision geospatial information. It is also expected to use various observational functions for environmental monitoring of coastal areas and to use and research for environmental conservation in vegetation areas. In this study, we report on the possibility of classification of sediment in shallow sea area using satellite images which are simulated to ALOS-3 observation performance from the viewpoint of conservation of coastal environment. The area of study was a coral reef in the Yaeyama islands of Okinawa Prefecture, including Ishigaki Island, where water quality was relatively stable in coastal shallow waters. The satellite images as ALOS-3 simulation are Digital Globe Worldview (WV), close to AlOS-3 's observation performance. The WV data (ortho-rectified) is used to resize the WISH equivalent to 0.8 m (panchromatic) and 3.2 m (multi-color) for our analysis.The results of the analysis by ALOS/AVNIR-2 near the season of WV’ s observing date/time are also shown as a comparison. In the sediment identification of shallow sea area by satellite remote sensing, the effect of the water depth (tide level) difference is a problem, and a depth correction algorithm has been proposed as one of the methods to reduce the influence. This algorithm is based on the basic principle (Lyzenga, 1978) in which the logarithm of the pixel value (digital number) in the two wavelength bands in the same bottom quality is constant slope not involved in the depth, the index of the bottom quality was removed information of the depth it is intended to calculate.
The results of analysis using Coastal and Red Edge which are the features of ALOS-3 sensor are also reported. Our resuls showed that it can be distinguished more in detail than AVNIR-2(10m) so far. ALOS-3 data is expected to be used as a coastal environmental monitoring tool.

Keywords: ALOS-3, WISH, ALOS, Bottom Index, Coral Reef

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Evaluation of the impact of nomadism and settlement on grassland based on GPS observation data

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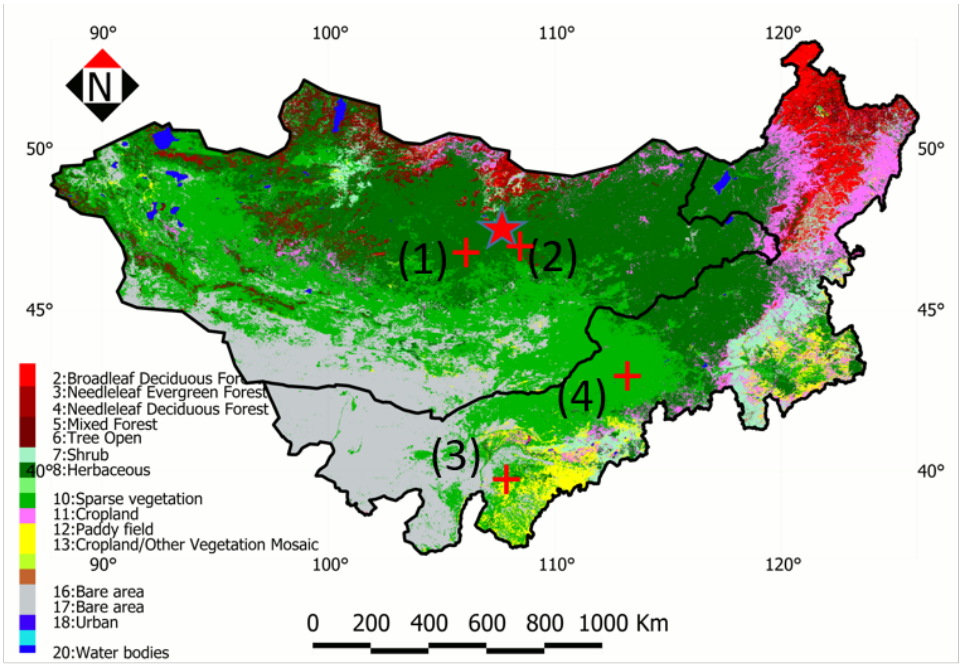

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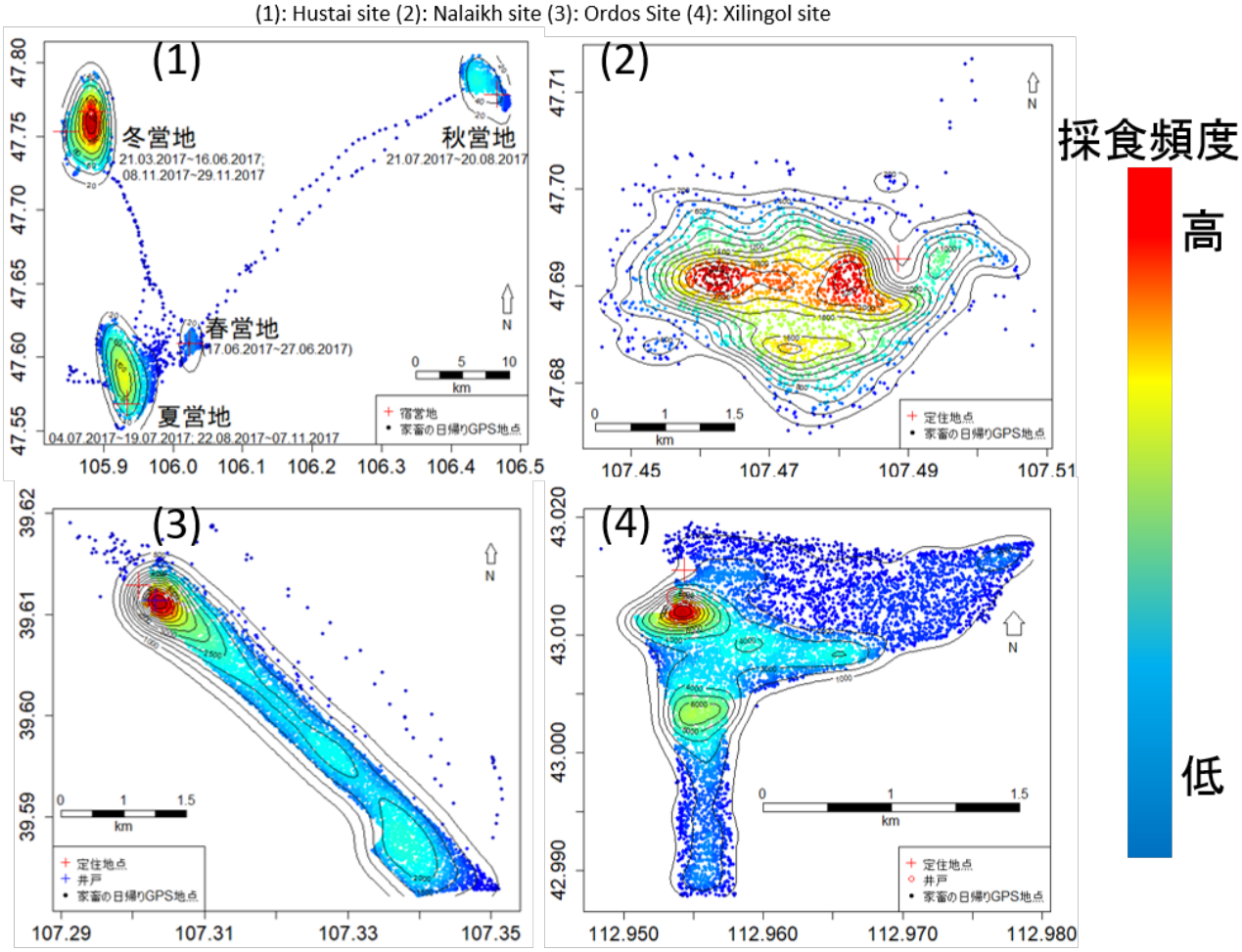

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[J] Poster | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_4

[H-CG29] Coastal wetlands: geomorphologic, biologic and anthropogenic processes

convener:Kiyoshi Fujimoto(Nanzan University)

Coastal wetlands are very fragile environment against external environmental changes such as sea-level rise and anthropogenic impacts. On the other hand, coastal wetlands have a significant role as a place for carbon sequestration in the belowground as well as the aboveground. This session will discuss the geomorphologic, biologic and anthropogenic processes on the coastal wetlands in the various climate zones during the Holocene. For example, coastal wetlands in the tropics have evolved with the development of wetland forests such as mangrove forest, peat swamp forest and fresh water swamp forest. The most significant process for habitat formation and maintenance of the former two forests are peat production and decomposition, which are also significant processes on the coastal lowlands in the temperate and subarctic zones, though the mechanism of the processes might be different. Geomorphological processes such as sedimentation and erosion by fluvial and marine processes are also important for all of coastal wetlands. However, the environment of coastal wetlands has been destroyed by various human activities such as deforestation, agriculture land development, peat mining, and shrimp firming in and around mangrove forests in recent years. We would like to invite the wide discipline of research papers on not only the natural processes but also the anthropogenic processes in order to offer the scientific basis for creating sustainable management systems on the coastal wetlands in the future.

[HCG29-P01] Progressing influences of rapid sea-level rise in the mangrove peat depositional area: Relationship between tree density of *Rhizophora* species and ground level dynamics

*Kiyoshi Fujimoto[1], Kenji Ono[2], Shin Watanabe[3], Shingo Taniguchi[3], Keita Furukawa[4], Yasumasa Hirata[2], Kodai Hasada[5], Saimon Lihpai[6] (1.Nanzan University, 2.Forestry and Forest Products Research Institute, 3.University of the Ryukyus, 4.Yokohama National University, 5.Hosei University, 6.Pohnpei State Government, FSM)

[HCG29-P02] Preliminary measurement of surface erosion and sedimentation in mangrove forests

*Keita Furukawa[1] (1.Graduate School Education Center, Yokohama National University)

[HCG29-P03] Estimation of fine root productivity of mangroves based on ingrowth core method on *Avicennia* forest in Panay Island, Philippines

*ONO Kenji[1], Rempei SUWA[2], Rene ROLLON[3], Ariel C. BLANCO[3], Giannina MARIE G. ALBANO[3], Green ANN A. CRUZ[3], Yasumin H. PRIMAVERA-TIROL[4], Ronald J. MALIO[4], Kazuo NADAOKA[5] (1.Forestry and Forest Products Research Institute, 2.Japan International Research Center for Agricultural Science, 3.University of the Philippines, 4.Aklan State University, 5.Tokyo Institute of Technology)

[HCG29-P04] The impact of reconstruction work for the ecosystem of marshes which appeared after Great East Japan Earthquake. A case of Nonoshima island, Shiogama, Miyagi prefecture.

*Rin Yamaguchi[1] (1.KyotoUniversity Faculty of letters)

Progressing influences of rapid sea-level rise in the mangrove peat depositional area: Relationship between tree density of *Rhizophora* species and ground level dynamics

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1. Nanzan University, 2. Forestry and Forest Products Research Institute, 3. University of the Ryukyus, 4. Yokohama National University, 5. Hosei University, 6. Pohnpei State Government, FSM

In the western Pacific low-latitude region between the Philippines and Micronesia, the sea level is rising at over 10 mm/yr (IPCC 2013). Mangrove habitats on the oceanic islands are generally situated in the low sediments inflow areas. In such areas, *Rhizophora* pure forest is formed as a pioneer community and mangrove peat is created. However, the mangrove peat accumulation rate is considered to decrease with the vegetation succession because of the decline of tree density of *Rhizophora* sp. The mangrove communities decreased mangrove peat accumulation rate is possibly affected by sea-level rise first. In Pohnpei Island, Micronesia, the surface erosion is not recognized in the *Rhizophora stylosa* and *Rhizophora apiculata* communities, while it is recognized in the communities dominated by other species.

We will report first the ground level dynamics for a year by observing the aboveground length of piles installed into the peat deposits up to the base for the main mangrove communities in Pohnpei. Secondly, we will analyze the relationship between the tree density of *R. apiculata* and ground level dynamics using the 20-years monitoring data in a 1 ha permanent plot (PE: 50m by 200 m) established in an estuary type mangrove habitat.

We set five stainless piles with 5 mm in diameter for each observation plot. The observation plots were established seaward and landward sites of four permanent plots, i.e., PR , PC, PS and PK, whose dominant species are *R. stylosa*, *R. apiculata*, *Sonneratia alba* and *Bruguiera gymnorrhiza*, respectively. We could not set piles in PE because of the deep mangrove peat over 5 m. The ground level increased in PR and PC, indicating mangrove peat accumulation against sea-level rise, while it decreased in PS and PK, indicating surface erosion.

For PE, we created ground level maps at 1994 and 2014 using ArcGIS 3D Analyst and calculated average ground level by ten meter square subplot for each ground level map. The deference between the two time points was used for the data of ground level change. The tree density of *R. apiculata* was calculated by counting the existing tree numbers in each subplot. The analyses showed a strong positive association in 0 to 50 m and 150 to 200 m zones between the *Rhizophora* tree density and ground level change, whereas the ground level between 50 and 150 m zone, in which a tidal creek is located, increased independently of the *Rhizophora* density.

Keywords: Mangrove community, Mangrove peat, Sea-level rise, Surface erosion, Oceanic islands

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Preliminary measurement of surface erosion and sedimentation in mangrove forests

*Keita Furukawa[1]

1. Graduate School Education Center, Yokohama National University

Preliminary measurement for detecting sea level rise (SLR) effects on mangrove forests has been done at Iriomote Island, Japan and Ponpei Island, Federal States of Micronesia in 2018. The short term SLR effects were measured by surface erosion and sedimentation. If sedimentation rate on a mangrove forest floor is faster enough to catch up with SLR, the forest will adapt on the change (Fujimoto et.al. 1989). Nevertheless, if it is slower than SLR, or erosion rate becomes greater than sedimentation rate, the forest will NOT adapt on the change (Furukawa et.al. 2002).

Sedimentation rate has been observed by 7 cm diameter sediment traps set on the forest floor. Organic matters in the trapped sediment has been checked by simplified Ignition Loss test by 400 degC burning. Sedimentation pattern was determined using simple relation i.e. under the well mixed sediment transport condition, sedimentation rate is decayed naturalized logarithmically from sediment supply point (Furukawa et.al 1997). Erosion rate has been calculated by subtraction of sedimentation rate from observed net flux. It was observed by high frequency (1 min.) sampling of water level and suspended sediment concentration at border of the forest and sea.

Various observation sites gave different pattern but same order of sedimentation and erosion could be happen in the forests. For further consideration, following points should be studied i.e. 1) clarification of detail sediment transport mechanism by sheet flow occurring inundation and drained timing, 2) clarification of sediment transport mechanism change due to tidal range, and 3) clarification of sediment transport through secondary creeks.

This research has been done as a part of “Mangrove forests community situation understanding against SLR.”

Keywords: Sea Level Rise, Adaptation of ecosystem, Mangrove forests, Sediment transport

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Estimation of fine root productivity of mangroves based on ingrowth core method on *Avicennia* forest in Panay Island, Philippines

*ONO Kenji[1], Rempei SUWA[2], Rene ROLLON[3], Ariel C. BLANCO[3], Giannina MARIE G. ALBANO[3], Green ANN A. CRUZ[3], Yasumin H. PRIMAVERA-TIROL[4], Ronald J. MALIO[4], Kazuo NADAOKA[5]

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To accurately evaluate the storing and sequestering processes of carbon of mangrove ecosystems in tropical and subtropical regions, it is necessary to determine the fine root productivity in mangrove forests. It is because high productivity of mangrove fine root highly contributes the huge carbon storage of mangrove ecosystem, especially their substratum. In the present study, we aimed to estimate the fine root productivity of *Avicennia* forest in KII eco-park in northern region of Panay Island, Philippines.

Ingrowth core experiment was conducted according to Fujimaki et al. (2004 PLSO) to estimate the annual production rate of fine root. Two transects (125 m in length) were set at each interior and seaside positions in KII eco-park, where have a different tidal frequency. Moreover, three plots were set up at respective transects and each twelve mesh cores, i.e., ingrowth cores were put on the mangrove forest floor in one plot at February, 2018. 4 cores had been already collected from the plots at September, 2018, picked up all fine roots from cores, determined their masses, and estimated their annual production rates.

Annual fine root production of *Avicennia* forest in KII eco-park were estimated to be 6.1 ±2.8 Mg ha^{-1} $year^{-1}$ at interior and 7.1 ±6.3 Mg ha^{-1} $year^{-1}$ at seaside respectively, which were based on the data of a half-year incubation cores.

These results indicate that FRP in mangrove forests was generally equal and/or relatively high compared with values previously recorded for *Avicennia* forests (Poungparn et al. 2012, 2015).

Keywords: fine root productivity, Avicennia, Panay Island

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The impact of reconstruction work for the ecosystem of marshes which appeared after Great East Japan Earthquake. A case of Nonoshima island, Shiogama, Miyagi prefecture.

*Rin Yamaguchi[1]

1. KyotoUniversity Faculty of letters

Many tidelands and salt marshes emerged in a 'Sanriku' coastal area, struck by tsunami and ground subsidence which is caused by Great East Japan Earthquake. Japanese Ministry of Environment(MOE) undertook investigation of some salt marshes, revealing that some endangered species which are important for biodiversity preservation(ex. *Cybister cinensis*, *Ruppia rosellata*) appeared there. With this investigation, many researchers conducted study about plant diversity in the newly-formed salt marshes, reporting that vulnerable plants grows there.
Nevertheless, the fauna and the flora of the newly-formed salt marshes are threatened because most of them are subject to reconstruction work which reclaims land of 200m in width and 2.9m in height from the groundwater table inside the seawalls.Consequently, almost all newly-formed salt marshes disappeared.
Government designated 12 sanctuary and made the setback of seawalls to absorb their impacts on the fauna and the flora. The sustainable research for the plant diversity has been conducted in the sanctuaries, proving that the policy has succeed in plant diversity preservation to some extent. However, there has been little study done concerning the newly-formed salt marshes which had been reclaimed, hence the impact of reconstruction work on them is not made clear enough.
The present study was undertaken to reveal the impact of reconstruction work on the newly-formed salt marsh, investigating the succession of vegetation, fauna and flora. The research was conducted at the newly-formed salt marsh in Nonoshima Island,Shiogama, Miyagi prefecture. The vegetation maps were made to illustrate the vegetation succession from the satellite photographs of different periods and the fauna and the flora were also investigated.
The results of this study as follows:
・The water area has decreased by the reclamation.
・The vegetation succession is found after the complementing of reclamation.
・*Pocambarus clarkii* and *Solidago canadensis* var. *scabra*, assigned as the invasive alien species by MOE have invaded there.

Keywords: Marsh, Earthquake, Ecosystem, newly-formed salt marsh, vegetation map

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We will report first the ground level dynamics for a year by observing the aboveground length of piles installed into the peat deposits up to the base for the main mangrove communities in Pohnpei. Secondly, we will analyze the relationship between the tree density of *R. apiculata* and ground level dynamics using the 20-years monitoring data in a 1 ha permanent plot (PE: 50m by 200 m) established in an estuary type mangrove habitat.

We set five stainless piles with 5 mm in diameter for each observation plot. The observation plots were established seaward and landward sites of four permanent plots, i.e., PR , PC, PS and PK, whose dominant species are *R. stylosa*, *R. apiculata*, *Sonneratia alba* and *Bruguiera gymnorrhiza*, respectively. We could not set piles in PE because of the deep mangrove peat over 5 m. The ground level increased in PR and PC, indicating mangrove peat accumulation against sea-level rise, while it decreased in PS and PK, indicating surface erosion.

For PE, we created ground level maps at 1994 and 2014 using ArcGIS 3D Analyst and calculated average ground level by ten meter square subplot for each ground level map. The deference between the two time points was used for the data of ground level change. The tree density of *R. apiculata* was calculated by counting the existing tree numbers in each subplot. The analyses showed a strong positive association in 0 to 50 m and 150 to 200 m zones between the *Rhizophora* tree density and ground level change, whereas the ground level between 50 and 150 m zone, in which a tidal creek is located, increased independently of the *Rhizophora* density.

Keywords: Mangrove community, Mangrove peat, Sea-level rise, Surface erosion, Oceanic islands

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Preliminary measurement of surface erosion and sedimentation in mangrove forests

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Preliminary measurement for detecting sea level rise (SLR) effects on mangrove forests has been done at Iriomote Island, Japan and Ponpei Island, Federal States of Micronesia in 2018. The short term SLR effects were measured by surface erosion and sedimentation. If sedimentation rate on a mangrove forest floor is faster enough to catch up with SLR, the forest will adapt on the change (Fujimoto et.al. 1989). Nevertheless, if it is slower than SLR, or erosion rate becomes greater than sedimentation rate, the forest will NOT adapt on the change (Furukawa et.al. 2002).

Sedimentation rate has been observed by 7 cm diameter sediment traps set on the forest floor. Organic matters in the trapped sediment has been checked by simplified Ignition Loss test by 400 degC burning. Sedimentation pattern was determined using simple relation i.e. under the well mixed sediment transport condition, sedimentation rate is decayed naturalized logarithmically from sediment supply point (Furukawa et.al 1997). Erosion rate has been calculated by subtraction of sedimentation rate from observed net flux. It was observed by high frequency (1 min.) sampling of water level and suspended sediment concentration at border of the forest and sea.

Various observation sites gave different pattern but same order of sedimentation and erosion could be happen in the forests. For further consideration, following points should be studied i.e. 1) clarification of detail sediment transport mechanism by sheet flow occurring inundation and drained timing, 2) clarification of sediment transport mechanism change due to tidal range, and 3) clarification of sediment transport through secondary creeks.

This research has been done as a part of “Mangrove forests community situation understanding against SLR.”

Keywords: Sea Level Rise, Adaptation of ecosystem, Mangrove forests, Sediment transport

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Estimation of fine root productivity of mangroves based on ingrowth core method on *Avicennia* forest in Panay Island, Philippines

*ONO Kenji[1], Rempei SUWA[2], Rene ROLLON[3], Ariel C. BLANCO[3], Giannina MARIE G. ALBANO[3], Green ANN A. CRUZ[3], Yasumin H. PRIMAVERA-TIROL[4], Ronald J. MALIO[4], Kazuo NADAOKA[5]

1. Forestry and Forest Products Research Institute, 2. Japan International Research Center for Agricultural Science, 3. University of the Philippines, 4. Aklan State University, 5. Tokyo Institute of Technology

To accurately evaluate the storing and sequestering processes of carbon of mangrove ecosystems in tropical and subtropical regions, it is necessary to determine the fine root productivity in mangrove forests. It is because high productivity of mangrove fine root highly contributes the huge carbon storage of mangrove ecosystem, especially their substratum. In the present study, we aimed to estimate the fine root productivity of *Avicennia* forest in KII eco-park in northern region of Panay Island, Philippines.

Ingrowth core experiment was conducted according to Fujimaki et al. (2004 PLSO) to estimate the annual production rate of fine root. Two transects (125 m in length) were set at each interior and seaside positions in KII eco-park, where have a different tidal frequency. Moreover, three plots were set up at respective transects and each twelve mesh cores, i.e., ingrowth cores were put on the mangrove forest floor in one plot at February, 2018. 4 cores had been already collected from the plots at September, 2018, picked up all fine roots from cores, determined their masses, and estimated their annual production rates.

Annual fine root production of *Avicennia* forest in KII eco-park were estimated to be 6.1 ±2.8 Mg ha^{-1} $year^{-1}$ at interior and 7.1 ±6.3 Mg ha^{-1} $year^{-1}$ at seaside respectively, which were based on the data of a half-year incubation cores.

These results indicate that FRP in mangrove forests was generally equal and/or relatively high compared with values previously recorded for *Avicennia* forests (Poungparn et al. 2012, 2015).

Keywords: fine root productivity, Avicennia, Panay Island

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The impact of reconstruction work for the ecosystem of marshes which appeared after Great East Japan Earthquake. A case of Nonoshima island, Shiogama, Miyagi prefecture.

*Rin Yamaguchi[1]

1. KyotoUniversity Faculty of letters

Many tidelands and salt marshes emerged in a 'Sanriku' coastal area, struck by tsunami and ground subsidence which is caused by Great East Japan Earthquake. Japanese Ministry of Environment(MOE) undertook investigation of some salt marshes, revealing that some endangered species which are important for biodiversity preservation(ex. *Cybister cinensis*, *Ruppia rosellata*) appeared there. With this investigation, many researchers conducted study about plant diversity in the newly-formed salt marshes, reporting that vulnerable plants grows there.
Nevertheless, the fauna and the flora of the newly-formed salt marshes are threatened because most of them are subject to reconstruction work which reclaims land of 200m in width and 2.9m in height from the groundwater table inside the seawalls.Consequently, almost all newly-formed salt marshes disappeared.
Government designated 12 sanctuary and made the setback of seawalls to absorb their impacts on the fauna and the flora. The sustainable research for the plant diversity has been conducted in the sanctuaries, proving that the policy has succeed in plant diversity preservation to some extent. However, there has been little study done concerning the newly-formed salt marshes which had been reclaimed, hence the impact of reconstruction work on them is not made clear enough.
The present study was undertaken to reveal the impact of reconstruction work on the newly-formed salt marsh, investigating the succession of vegetation, fauna and flora. The research was conducted at the newly-formed salt marsh in Nonoshima Island,Shiogama, Miyagi prefecture. The vegetation maps were made to illustrate the vegetation succession from the satellite photographs of different periods and the fauna and the flora were also investigated.
The results of this study as follows:
・The water area has decreased by the reclamation.
・The vegetation succession is found after the complementing of reclamation.
・*Pocambarus clarkii* and *Solidago canadensis* var. *scabra*, assigned as the invasive alien species by MOE have invaded there.

Keywords: Marsh, Earthquake, Ecosystem, newly-formed salt marsh, vegetation map

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[J] Poster | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_5

[H-CG30] Safety of nuclear power plants against inland earthquakes

convener:Daisuke Suetsugu(Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology), Satoshi Kaneshima(Department of Earth and Planetary Sciences, Kyushu University), Takeshi Sagiya(Disaster Mitigation Research Center, Nagoya University), Kohta Juraku(Department of Humanities, Social and Health Sciences, School of Engineering, Tokyo Denki University)

We have organized sessions in the JpGU meeting on nuclear power plants in Japan mainly from a viewpoint of earthquake science since 2013. Topics in the sessions include risks of nuclear power plants related to earthquakes, volcanic activities and tsunamis, as well as the problem of communication gap between scientists and engineers on those risks.
In the 2019 JpGU meeting, we propose the session that focuses mainly safety against inland earthquakes. For a last decade, strong inland earthquakes occurred, such 2007 Off Niigata-Chuetsu earthquake (M6.8), 2008 Iwate-Miyagi earthquake (M6.9), 2016 Kumamoto earthquake, which did damage to regions near the earthquakes. Recently, 2018 Hokkaido east Iburi earthquake (M6.7) gave devastating effects to the epicentral area. Considering the high activity of inland earthquakes, it is important to reconsider the safety measures of nuclear power plants against strong inland earthquakes.
We would encourage discussions from a broad viewpoint across science and engineering, such as evaluation of strong motion due to inland earthquake and anti-seismic capability of nuclear power plants.
We welcome papers of other topics relevant to relationship of earthquake science and nuclear power plants, too.

[HCG30-P01] Lessons from recent inland earthquakes in the Japan Islands

*Takeshi Sagiya[1] (1.Disaster Mitigation Research Center, Nagoya University)

[HCG30-P02] A review of inland earthquakes unlinked to active faults

*Daisuke Suetsugu[1] (1.Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology)

[HCG30-P03] Summary of 2018 JPGU session about the high-level radioactive waste disposal program

*Satoshi Kaneshima[1] (1.Department of Earth and Planetary Sciences, Kyushu University)

[HCG30-P04] Calculation Automates the Decision?: Socio-Technical Perspectives of Simulation Technology for Nuclear Risk Evaluation

*Kohta Juraku[1] (1.Department of Humanities, Social and Health Sciences, School of Engineering, Tokyo Denki University)

Lessons from recent inland earthquakes in the Japan Islands

*Takeshi Sagiya[1]

1. Disaster Mitigation Research Center, Nagoya University

Large earthquakes occurring inland are highly disastrous compared with their magnitude. In Japan, the 1995 Kobe Earthquake demonstrated how much tremendous damage such earthquakes could cause. Following this disaster, the Japanese government established the Headquarters for Earthquake Research Promotion (HERP) to promote investigation of earthquake research, including extensive investigation of active faults, for the purpose of better understand potential seismic hazard throughout the country. The achievements of HERP is summarized as the “Seismic hazard maps for Japan”, first published in 2005 and has been updated almost every year. In spite of such an effort, however, recent large earthquakes indicate that our knowledge about seismic hazard is still limited and thus our preparation is never complete. On 6 September 2018, a M_w6.6 earthquake occurred in the Iburi district of Hokkaido, named as the 2018 Eastern Iburi earthquake. The focal depth of this earthquake was 37 km. The largest intensity was JMA intensity VII and the observed largest acceleration was 1505 gal. 41 people were killed mainly due to landslides and liquefaction occurred over a wide area including a part of Tomakomai and Sapporo. Considering the earthquake magnitude and its focal depth, there was no surface rupture and active fault investigation is of no use to identify the potential of this earthquake. It is important to point out that even an earthquake of this size with the focal depth of 37 km can still cause such strong shaking. Evaluation of seismic potential and its possible disastrous consequences should be considered in the light of new seismic observations.

Keywords: seismic hazard, Japan islands, inland earthquakes

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A review of inland earthquakes unlinked to active faults

*Daisuke Suetsugu[1]

1. Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology

For a last decade, strong inland earthquakes occurred, such 2007 Off Niigata-Chuetsu earthquake (M6.8), 2008 Iwate-Miyagi earthquake (M6.9), 2016 Kumamoto earthquake, which did damage to regions near the earthquakes. Recently, 2018 Hokkaido east Iburi earthquake (M6.7) gave devastating effects to the epicentral area. Considering the high activity of inland earthquakes, it is important to reconsider the safety measures of nuclear power plants against strong inland earthquakes. In the presentation, we will review character and nature of the inland earthquakes that were not directly linked to active faults.

Keywords: Nuclear power plant, Inland earthquake, Active fault

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Summary of 2018 JPGU session about the high-level radioactive waste disposal program

*Satoshi Kaneshima[1]

1. Department of Earth and Planetary Sciences, Kyushu University

In this poster I revisit and summarize the discussions in the session about Japanese program for high-level radioactive waste disposal, which was held at the 2018 JPGU meeting. Geophysical and geological issues discussed in association with high level radioactive waste management underground were diverse: estimates of strong seismic ground motions intimately linked with capability of forecasting future inland large earthquakes, lack of accurate methods to detect active faults invisible at Earth’ s surface, need for accurate evaluations of underground geometry and future activity of the faults already recognized, predicting pass ways of ground water, maintaining redox state of underground disposal sites, and so on. The presentations given by the experts of each issue and the following discussions elucidated serious difficulty in making reliable scientific predictions that ensure long-term safety of disposal sites. A consensus appears to be shared on the urgent need for starting some disposal program as soon as possible, however, based on the recognition of the situation our country faces that plenty of nuclear wastes already produced await being disposed somehow and several power plants shut down after the 2011 Tohoku earthquake were recently brought into operation again. This is a conundrum that Japanese society needs to confront and on which public discussions are required in the places where people of many different fields and back grounds are involved. Earth science community at least needs to enhance conversations with engineering people.

Keywords: high-level radioactive waste disposal, public discussions

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Calculation Automates the Decision?: Socio-Technical Perspectives of Simulation Technology for Nuclear Risk Evaluation

*Kohta Juraku[1]

1. Department of Humanities, Social and Health Sciences, School of Engineering, Tokyo Denki University

It is a widespread notion that quantitative calculation of technological risk should help our better decisions concerning risk management and emergency response for nuclear utilization. However, sometimes it is believed more than to “help” the decision, but to “automate” it. After the Fukushima nuclear accident in 2011, it has been criticized that the Japanese nuclear community were overdependent on such a belief, while neglected to establish the capacity and institutional framework to utilize it in appropriate manner.

Our qualitative study revealed that this kind of belief is still alive, although a lot of efforts to overcome it. We have witnessed highly polarized and stereotyped disputes: for example, System for Prediction of Environmental Emergency Dose Information (SPEEDI) are deemed either totally useful, or utterly useless. The imaginaries held by relevant stakeholders on methods of risk quantification and its consequences are contested, but at the same time partly unanimous.

To analyze the mechanism which persistently reproduces the “Calculation Automates the Decision” belief, the author conducted a study on the policy process centering on those simulation techniques. He recently co-authored a book chapter on the SPEEDI case, in which they discussed the dysfunction of this belief, such as the obstruction of practical, effective implementation of such technologies. Socio-political interactions among relevant actors, technical concepts, legal frameworks and social atmosphere will be critically analyzed, to identify the key factors which encouraged the very particular evolution process of institutional psychological overdependence on the belief. The author believe that he could contribute to the discussion centering on the risk caused by possible strong ground motion by major inland earthquake.

Keywords: Simulation Technology, Uncertainty, Risk Evaluation, SPEEDI

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[J] Poster | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_21

[H-CG30] Safety of nuclear power plants against inland earthquakes

convener:Daisuke Suetsugu(Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology), Satoshi Kaneshima(Department of Earth and Planetary Sciences, Kyushu University), Takeshi Sagiya(Disaster Mitigation Research Center, Nagoya University), Kohta Juraku(Department of Humanities, Social and Health Sciences, School of Engineering, Tokyo Denki University)

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We would encourage discussions from a broad viewpoint across science and engineering, such as evaluation of strong motion due to inland earthquake and anti-seismic capability of nuclear power plants.
We welcome papers of other topics relevant to relationship of earthquake science and nuclear power plants, too.

[HCG30-P01] Lessons from recent inland earthquakes in the Japan Islands

*Takeshi Sagiya[1] (1.Disaster Mitigation Research Center, Nagoya University)

[HCG30-P02] A review of inland earthquakes unlinked to active faults

*Daisuke Suetsugu[1] (1.Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology)

[HCG30-P03] Summary of 2018 JPGU session about the high-level radioactive waste disposal program

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Keywords: seismic hazard, Japan islands, inland earthquakes

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*Daisuke Suetsugu[1]

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*Satoshi Kaneshima[1]

1. Department of Earth and Planetary Sciences, Kyushu University

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Keywords: Simulation Technology, Uncertainty, Risk Evaluation, SPEEDI

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[J] Oral | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 104 1F

[H-CG30] Safety of nuclear power plants against inland earthquakes

convener:Daisuke Suetsugu(Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology), Satoshi Kaneshima(Department of Earth and Planetary Sciences, Kyushu University), Takeshi Sagiya(Disaster Mitigation Research Center, Nagoya University), Kohta Juraku(Department of Humanities, Social and Health Sciences, School of Engineering, Tokyo Denki University), Chairperson:Daisuke Suetsugu, Kohta Juraku

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3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HCG30-01] Thickness of the seismogenic layer beneath the Japanese Islands and its relation to crustal earthquakes

*Junichi Nakajima[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HCG30-02] Problems with active fault evaluation in nuclear safety regulation

*Yasuhiro Suzuki[1] (1.Nagoya University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HCG30-03] The longer active fault is, is the larger ground motion generated? – Surface and buried rupture earthquakes-

*Takao Kagawa[1] (1.Tottori University Graduate School of Engineering)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HCG30-04] Seismic safety of nuclear power plants against inland crustal earthquakes and the "science vs. engineering problem"

*Katsuhiko Ishibashi[1] (1.Emeritus Professor, Kobe University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[HCG30-05] Challenges to Seismic Safety of Nuclear Power Plants

*Tatsuya Itoi[1] (1.The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[HCG30-06] Strong motion at Ooi nuclear power plant

*Kunihiko Shimazaki[1] (1.University of Tokyo)

Thickness of the seismogenic layer beneath the Japanese Islands and its relation to crustal earthquakes

*Junichi Nakajima[1]

1. Department of Earth and Planetary Sciences, Tokyo Institute of Technology

The thickness of the seismogenic layer is one of the fundamental parameters for earthquake hazard analysis. Large earthquakes often rupture the entire brittle seismogenic layer, and so the thickness of the seismogenic layer is a primary control on the size of earthquakes. Omuralieva et al. (2012) estimated the cut-off depth (D90) of crustal seismicity beneath Japan using a high-quality seismic catalogue of the Japan Meteorological Agency. D90 is defined as the depth above which 90% of the earthquakes occur. The obtained D90 shows a considerable lateral variation, ranging from ~5 km to ~40 km. The D90 is deep along the Pacific coast of eastern Japan, while it is locally shallow around volcanic areas. These lateral variations in D90 are inversely correlated to values of surface heat flow. In this talk, I summarize the recent result of D90 in Japan and discuss the relation among D90, thermal structure, and the size of crustal earthquakes.

Keywords: Earthquake, seismogenic layer

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Problems with active fault evaluation in nuclear safety regulation

*Yasuhiro Suzuki[1]

1. Nagoya University

There are various factors behind the underestimation of active faults during the safety review of nuclear power plants. I have disclosed this problem in my books (“Nuclear Power Plants and Active Faults” published by Iwanami-Shoten in 2013, and “Active Faults and Nuclear Regulation in Japan”, in-edit). In the past, safety review was conducted in two stages—site review and seismic review, and active fault survey was conducted only in the latter. Therefore, we could not use active fault information for site determination. Moreover, the safety regulation rules (Regulatory Guide for Reviewing Seismic Design) were bylaws of government authorities that did not possess external binding power. Furthermore, it allowed arbitrariness in interpreting the definition of active faults. In the above-mentioned case, although problems related to laws and ordinances have improved due to the establishment of New Regulatory Requirements after the formation of the Nuclear Regulation Authority (NRA), the problem of the NRA itself having no authority to investigate remains. In this presentation, I discuss issues of active fault evaluation in safety regulation.

Usually, the construction of nuclear plants should be conducted as follows: (1) determine if an active fault exists in the premises or in the vicinity, ② estimate earthquake ground motion and ground deformation by active faulting before designing, or ③ avoid. This flow is the basic policy of the NRA examination team that I was a part of, for the New Regulatory Requirements. ③ "Avoid" means moving the location or refraining from constructing at the site. However, there was no corresponding description in the earlier regulatory guide. The New Regulatory Requirements prohibit important facilities from being installed on the outcrop of "faults etc. that may possibly activate in the future". In addition, operating is not permitted unless it meets the requirements. While there have been objections to this, we can discuss again how to better understand "avoiding". However, revising New Regulatory Requirements should be based on social consensus. I will discuss here several scientific subjects regarding ① "active fault recognition" and ② "prediction of earthquake motion and displacement".

Keywords: Nuclear power Plant, Active fault, Nuclear Regulation

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The longer active fault is, is the larger ground motion generated? –Surface and buried rupture earthquakes-

*Takao Kagawa[1]

1. Tottori University Graduate School of Engineering

Ground motion characteristics from surface and buried rupture earthquakes are demonstrated. Magnitude of surface rupture earthquake is large and it causes heavy damages in wide area. However, it is considered that ground motions from buried rupture earthquake is larger than those from surface rupture earthquake assuming same magnitude for both types of earthquake.

In case of aseismic design for important facilities, fault rupture scenarios tend to be conservative such as setting a long active fault with large magnitude. The larger magnitude is, the longer predominant period of ground motion from the earthquake is. However, ground motion in short period range that really affects on the target facility does not grow so large. Short period ground motion is affected more by fault distance than magnitude. Unfortunately, it is possible that larger ground motions in short period range are generated from small buried earthquakes than from large surface earthquake. Furthermore, probability of small buried rupture earthquakes are larger than that of large characteristic surface rupture earthquake. It might be an important issue for important facilities located in specific regions.

Keywords: Active fault, Ground motion, Surface rupture earthquakes, Buried rupture earthquakes

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Seismic safety of nuclear power plants against inland crustal earthquakes and the "science vs. engineering problem"

*Katsuhiko Ishibashi[1]

1. Emeritus Professor, Kobe University

The seismic safety of nuclear power plants (NPPs) against inland crustal earthquakes has been a big problem in Japan since a nuclear reactor developed in the United Kingdom, an aseismic country, was introduced as the first commercial reactor in the 1950s (e.g., Ishibashi, 2015). However, even now, this problem has not been settled at all. In this presentation, first I review various problems of seismic safety of NPPs related to inland crustal earthquakes referring to the ongoing safety regulation. Then, I discuss the so-called "science vs. engineering problem" concerning NPPs' seismic safety.

The fundamental problem in the seismic safety of NPPs against inland crustal earthquakes is that the largest earthquakes which could affect each NPP severely by strong ground motion, or surface fault dislocation, or coseismic crustal deformation, or ground failures, or large tsunami, cannot be predicted precisely because of the intrinsic nature of earthquakes. Active faults don't indicate seismic fault planes of future earthquakes, and distribution of SMGAs (Strong Motion Generation Areas), stress drop values nor slip amounts on SMGAs cannot be known beforehand. Thickness of earthquake generation layers in the upper crust around each NPP is also obscure, though very important. In addition, prediction of occurrence and strong motion of slightly deep earthquakes in special tectonic environments such as the 2018 Hokkaido earthquake (M_J 6.7, H37km, maximum observed PGA 1796 Gal) is extremely difficult.

These essential difficulties bring underestimation of DBEGM (Design Basis Earthquake Ground Motion) or tsunami, and missing of possible crustal movement, which have actually occurred in several NPPs. Successive large aftershocks which may cause severe effects to a NPP damaged by the main shock is also a serious problem, but is not taken into account in NPPs' earthquake countermeasures. Next NPP accident in Japan may be brought about by this kind of phenomena.

Keywords: Nuclear power plants, Seismic safety, Inland crustal earthquakes, Evaluation of largest earthquake, Successive large aftershock, Science vs. engineering problem

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Challenges to Seismic Safety of Nuclear Power Plants

*Tatsuya Itoi[1]

1. The University of Tokyo

Risk of nuclear power plants under threat of earthquake is not only a function of seismic hazard but also a function of a complex socio-technology system related to nuclear power plants.

Characteristics of seismic hazard can be summarized as follows:

- Strong ground motion is a phenomenon which is spatially distributed and affects simultaneously in space

- We cannot identify a worst-case ground motion because of inherent variability of earthquake (aleatory uncertainty),

- Uncertainty due to our limitation of knowledge is another source of reason why we cannot identify worst-case ground motion (epistemic uncertainty),

- There exists large uncertainty in prediction of rare (usually large) earthquake because of large epistemic uncertainty. Large epistemic uncertainty can be observed as different judgements among experts on the same issue.

A complex socio-technology system related to nuclear power plants is composed both of physical subsystems and of human and organizational subsystems. This means that not only the capacity of physical systems but also organizational resourcefulness and framework to prepare for and deal with such events should be carefully examined, when we discuss the capacity of nuclear power plants under extreme earthquake.

When organizational resourcefulness and framework is discussed, a sensitivity and adaptation to social preferences is important. For example, safety requirements to nuclear power plants shifted and will shift over time.

What is equally important is that recognition that uncertainty related to seismic hazards are shared among stakeholders and framework to deal with it should be prepared. One of good practices is considered to be an introduction of a process like SSHAC process [1], where representing the center, body and range of technically defensible interpretation is an aim. It is also important to recognize that scientific knowledge on natural hazards like earthquake also grows and sometimes shifts over time. Integrated decision making

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process on nuclear safety issues which helps to ensure consistent and transparent decision should be a key to deal with these issues.

Refenrence
[1] USNRC: Updated Implementation Guidelines for SSHAC Hazard Studies (NUREG-2213), 2018.

Keywords: Seismic safety, Nuclear Power Plants

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Strong motion at Ooi nuclear power plant

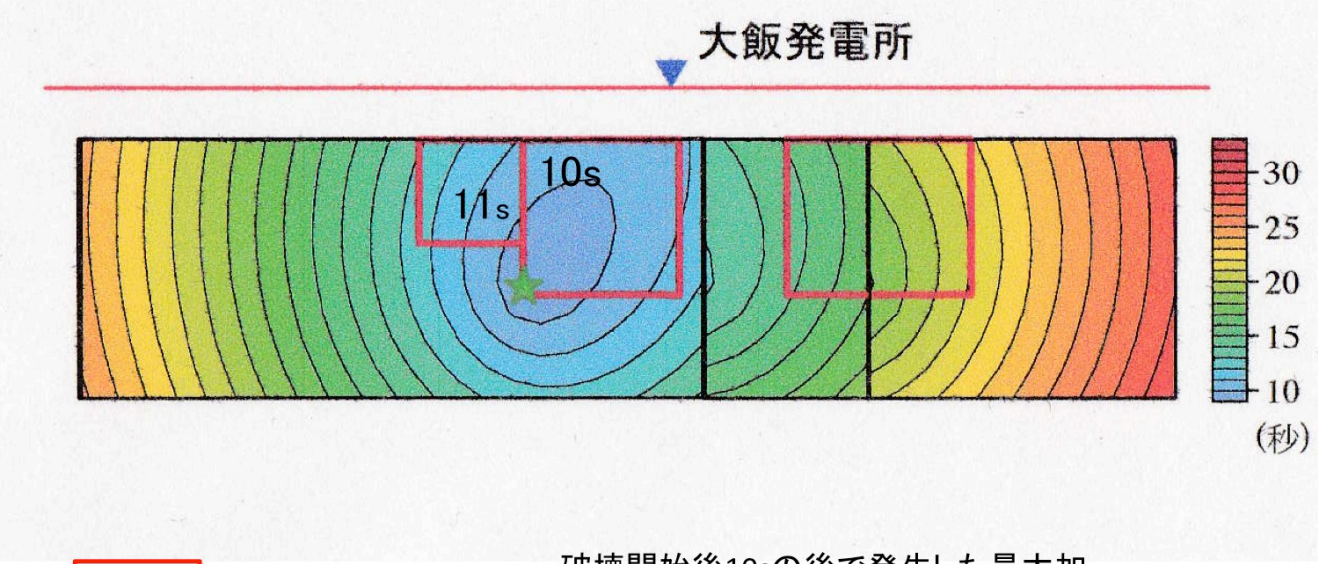
*Kunihiko Shimazaki[1]

1. University of Tokyo

The design basis seismic acceleration at Ooi Nuclear Power Plant is estimated as 856gal by using Irikura and Miyake (2001)'s 'recipe' and consideration on uncertainty in short-period spectral level. It appears to be smaller than so-called cliff edge acceleration estimated as 1260gal. However, more realistic acceleration would be greater than this cliff edge level.

Keywords: Ooi nuclear power plant, design basis ground motion, stress test

破壊開始点3・大飯発電所のアイソクロン



強震動生成域

破壊開始後10sの後で発生した最大加速度は、破壊が強震動生成域の端に達して発生したことがわかる。

原子力規制庁審査資料に加筆

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[J] Poster | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_5

[H-CG32] Interdisciplinary approach to earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Naofumi Yamaguchi(Center for Water Environment Studies, Ibaraki University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Hideko Takayanagi(Institute of Geology and Paleontology, Graduate School of Science, Tohoku University)

To understand landscape evolution and dynamics of erosion, transport and sedimentation of earth-surface materials, the latest results of multiple research fields including engineering and earth sciences will be presented. As well as any researches of sedimentology and sedimentary petrology, interaction between fluid, sediments and geomorphology is focused. Interdisciplinary discussions of science, disaster prevention and resource exploration will be expected.

[HCG32-P01] Abration process of gravel considered from shape change of beach gravel in Joetsu region, Niigata Prefecture,central Japan

*Jun Matsukaze[1], Masaaki Shirai[1], Takako UTSUGAWA[2] (1.Tokyo Metropolitan University, 2.Rissho University)

[HCG32-P02] A meander bar in the upper Koito River changed by floods

*Hiroko Okazaki[1] (1.Division of ecology & environmentology, Natural History and Institute, Chiba)

[HCG32-P03] Depositional environment based on grain size of surface sediments around Okinoerabu-jima, Tokuno-shima and Amami-oshima Islands

*Atsuko Amano[1] (1.National institute of Advanced Industrial Science and Technology)

[HCG32-P04] Effect of organic matter input on bioturbation in submarine channel-levee deposits: an example of the Izaki Olistolith in the Oligocene Nichinan Group

*Kazuki Kikuchi[1], Hajime Naruse[1] (1.Division of Earth and Planetary Sciences, Guraduate School of Science, Kyoto University)

[HCG32-P05] Effect of Freeze-Thaw Cycles on Bank Erosion Rate of Bedrock

*Jagriti Mishra[1], Takuya Inoue[1] (1.Civil Engineering Research Institute for Cold Region, Sapporo - Hokkaido, Japan)

[HCG32-P06] Implications for paleoenvironment and tectonic setting of Khujirt area, Northern Mongolia

*Bat-Orshikh Erdenetsogt[1], Ariunbold Erdene[2] (1.National University of Mongolia, 2.ErdGeo LLC)

[HCG32-P07] Petrographic characteristics of Middle Permian sandstones in Southern Mongolia and their geological implications

*Enkhbayar Bolormaa[1], Dashpuntsag Nansalmaa[1], Bat-Orshikh Erdenetsogt[1], Baigalmaa Norov[1], Bat Bold[1], Luvsanchultem Jargal[1], Avirmed Tulga[1] (1.National Unniversity of Mongolia)

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*Jun Matsukaze[1], Masaaki Shirai[1], Takako UTSUGAWA[2]

1. Tokyo Metropolitan University, 2. Rissho University

Various gravel species are observed on the gravel beach around the river mouths of the Joetsu region in the Niigata prefecture. Although several studies on size distribution of beach gravels and gravel species composition have been conducted, a study how gravels had been transported and abraded from river mouth along the beach were not carried out well. Transport and abrasion of beach gravels have hardly investigated enoughly. Studies on breaking and abrasion of beach gravels are expected to contribute understanding influence of sediment supply from river on beach processes.

The geologic and topographic features of Joetsu region differ between eastern and western sides of Itoigawa-Shizuoka Tectonic Line (e.g., Nagamori et al. 2010). From several gravel beaches located around river mouths, western sides of the Himekawa, Hayakawa and Nougawa rivers were selected for our study. At each survey site, 50 m long lines were set along the shoreline on the foreshore and the backshore. Along each line, three-axes (long, medium and short diameters) and roundness of “characteristic gravels” were measured. The “characteristimeansc gravel” means unique and distinguishable gravel species; granite, conglomerate and serpentinite (Himekawa River), quartz diorite (Hayakawa River) and rhyolite (Nougawa River) were selected as characteristic gravel species. Mean diameter calculated from cube root of the three axes and shape characteristics of the gravel on the shape classification diagram (Zingg, 1935) were investigated. Roundness was measured based mainly on roundness impression diagram (Krumbein, 1941).

Three axis and average diameter decreased with a distance from the river mouths. Long axis decreases distinctly and short axis decreased slightly and these tendencies accord well to the shape–diameter relationship of gravel which means gravel shape transfer from various to spherical via disk with decrease in gravel diameter.

Results of the Himekawa River in which granite, conglomerate and serpentinite were measured, show that conglomerate easily decreases its size with removal of clasts and consequently it keeps angular shape. In contrast, fine grained serpentinite hardly decreases its size and easily rounded. It suggests that grain/mineral size influence breaking/abrasion process of gravels.

Keywords: Beach Gravel, Particle size, Flatness, Roundness

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A meander bar in the upper Koito River changed by floods

*Hiroko Okazaki[1]

1. Division of ecology & environmentology, Natural History and Institute, Chiba

A meander bar is observed in the upper Koito River in the Boso Hills, Chiba Prefecture, central Japan. The study area of Boso Hills consist of alternations of sandstones and mudstones of the late Miocene Amatsu Formation. The upper Koito River is a plane-bed bedrock river and forms an incised meander. The bar distinctly was enlarged by lateral accretions and an increasing downstream of larger gravels during the floods caused by typhoons in autumn of 2017.

Keywords: meander bar, Koito River, flood

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Depositional environment based on grain size of surface sediments around Okinoerabu-jima, Tokuno-shima and Amami-oshima Islands

*Atsuko Amano[1]

1. National institute of Advanced Industrial Science and Technology

The spatial variation of grain size around Okinoerabu-jima, Tokuno-shima and Amami-oshima Islands located at Ryukyu Islands was compiled based on surface sediment samples and seabed photographs. Surface sediments around islands above the water depth of 600 m show gravels and very coarser sands characterized by high contents of calcium carbonate deposition mainly originated from coral, shells and briozoans. On the other hand, slope and flat areas below the water depth of 600 m are deposited medium-very fine sands (2-4ϕ) and shows to become a finer toward increasing in water depth, concave geometry including the Yoron and Okinoerabu basins in silt (4-7ϕ). These results indicate that hydrodynamics effects to sedimentary process decrease toward the increasing water depth and hemipelagic sediments are deposited in the basin. Ripple marks in the seafloor are observed at 66 sites by the seabed photographs. The water depths of these sites are mostly above 1000 m and the values of grain size 1-3ϕ. The current directions assumed by the ripple mark show complex changes and indicate that the bottom currents change affected by the microtopography.

Keywords: grain size, seabed photography, sedimentary environment

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Effect of organic matter input on bioturbation in submarine channel-levee deposits: an example of the Izaki Olistolith in the Oligocene Nichinan Group

*Kazuki Kikuchi[1], Hajime Naruse[1]

1. Division of Earth and Planetary Sciences, Guraduate School of Science, Kyoto University

This study focused on the variation of bioturbation intensity, ichnodiversity, and total organic carbon contents in actual submarine fan deposits, aiming to clarify their relationships. For sedimentological analysis, effects of sediment reworking by benthic animals have been estimated by indices of bioturbation intensity such as “ichnofabric indices” (*ii*; Droser and Bottjer, 1986) or “bioturbation indices” (BI; Taylor and Gorldring, 1993), which are represented by proportion of bioturbated area in outcrop surface. Recently, it was suggested that number of ichnotaxa (ichnodiversity) varies associated with changes of sedimentary environments, so that differences of ichnodiversity can also be an indicator of sedimentary environments (Buatois and Mángano, 2013; Callow et al., 2014). It is considered that various paleoenvironmental factors may affect the variation of bioturbation intensity or ichnodiversity (Orr, 2001). Particularly, fluctuation of organic matter input can significantly change the activities of benthic animals as shown in studies of biodiversity of recent shallow-marine benthic communities (e.g. Hyland et al., 2005). However, there are a few researches to discuss the relationships between ichnoassemblages and organic matter conditions (e.g. Wetzel and Uchman, 1998).

To this end, we observed the ichnoassemblage of the Izaki Olistolith within the Oligocene Nichinan Group in the southern part of Kyushu Island, southwest Japan. The Izaki Olistolith is composed of the alternating beds of turbidite sandstone and mudstone which are interpreted as deposits of a submarine channel-levee system. The lower part of the Izaki Olistolith consists of the mudstone dominated levee deposits and is overlain by the sandstone dominated channel-fill depoisits. A total of 22 ichnogenera and 24 ichnospecies occurred from the Izaki Olistolith. According to recent quantitative evaluation of ichnodiversity, the ichnodiversity in the channel-fill deposits was 1.74 times higher than that in the levee deposits (Kikuchi et al., 2018). The stratigraphic changes of bioturbation intensity and ichnodiversity were estimated by application of the image-resampling method proposed by Kikuchi et al. (2018). In addition, geochemical analysis was also examined in the Izaki Olistolith. The total organic carbon (TOC) and total nitrogen (TN) contents in 77 mudstone samples were measured with the element analyzer FLASH 2000 (Thermo Fisher Scientific).

Detailed analysis of ichnodiversity for each 1 m thick interval showed that the ichnodiversity in the Izaki Olistolith increased upward associated with paleoenvironmental changes from levee to channel environments and subsequent filling of the channel. In contrast, bioturbation intensity was constantly low, showing no significant trend in vertical changes. The TOC values range from 0.38 to 0.52wt.%. The mean values of TOC and TN were 0.46wt.% and 0.08wt.%, respectively. Both of TOC and TN values slightly increased upward.
The test of correlation suggested a significant positive correlation between the ichnodiversity and the mean of TOC for each 1 m thick interval. This implies that the variation of ichnodiversity in submarine fan deposits can be an indicator of organic matter input, especially under the condition of relatively low amount of input (0.3–0.5wt.%). In future work, it is necessary to analyze the deposits that have higher organic matter contents and investigate how bioturbation intensity and ichnodiversity change under the

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high organic matter input.

Keywords: ichnofossil, ichnodiversity, bioturbation intensity, total organic carbon

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Effect of Freeze-Thaw Cycles on Bank Erosion Rate of Bedrock

*Jagriti Mishra[1], Takuya Inoue[1]

1. Civil Engineering Research Institute for Cold Region, Sapporo - Hokkaido, Japan

Freeze-Thaw erosion happens when water penetrates through the cracks in rocks; freezes, and expands in volume, making the cracks bigger and eventually the rock weaker. Freeze-Thaw induced erosion accounts for 24% of the world land area and 55% of the total land area of the northern hemisphere making it the third major erosion type after water erosion and wind soil erosion. Even though, the effect of FT is massive, knowledge regarding how it effects rivers is scarce.

In this study, we have made an attempt to explore the change in the rate of erosion followed by a series of Freeze-Thaw cycles. We collected specimens from Rekifune river in Hokkaido, Japan. Each specimen was circular with a diameter of 220mm and height of 50mm. The specimens were immediately kept in air cushions to keep from drying, freezing or shock during transportation. In laboratory, until the test, the specimens were kept at room temperature, completely submerged in water to prevent the specimens from changes in water content.

Specimens were put through freeze-thaw cycle using a Freeze-Thaw Apparatus shown in Fig.1. The minimum temperature maintained to achieve freezing of the specimens was -18℃. The maximum temperature of the apparatus was maintained at 20℃ in order to achieve thawing of specimens. The time taken to achieve minimum and maximum temperatures was 3hours and 4hours respectively. The specimens were maintained at minimum and maximum temperature for 0.5 hours each. The total time taken for an entire cycle of freezing and thawing was 8 hours. After 1 cycle of FT, the surface layer peeled off; After 2nd cycle, the surface started getting flaky and peeling off; After 3rd cycle, a thin surface layer peeled off and the specimen disintegrated and couldn’ t be prepared for another FT cycle. The tensile strength of specimens decreased considerably after first FT cycle itself. The erosion rate of the specimens was measured using a rotation mill. The erosion rate of specimens decreased exponentially as shown in Fig.1. However, these samples were artificially frozen and thawed in a dry condition. In order to study the effect of FT cycles in wet conditions, we performed another set of experiments with specimens completely submerged in water. These specimens were kept outside the laboratory in order to study the effect of FT in natural conditions. The specimens were submerged under 400mm water depth. The top layer of the water was frozen within 1 night of setting up the specimens. After 1 month, the specimen was tested for its erosion rate. The erosion rate of the specimen became 2 times of specimen not put through FT cycle. Moreover, as shown in Fig.2; the specimens were flaking and disintegrating by itself due to FT. These results suggest that FT effects not only river banks, but river bed as well.

Keywords: Freeze-Thaw weathering, erosion rate, bedrock

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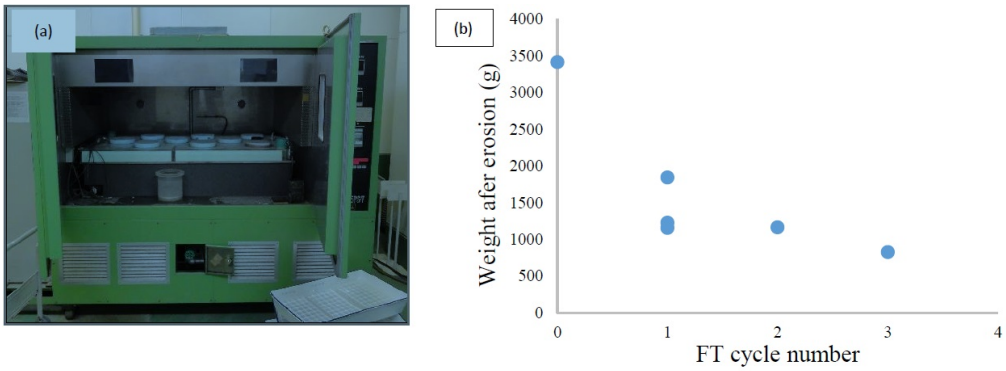

Fig.1 Experiment performed in dry conditions

(a) Apparatus used for mimicking FT cycle (b) Graph showing decrease erosion rate with respect to number of FT cycle.

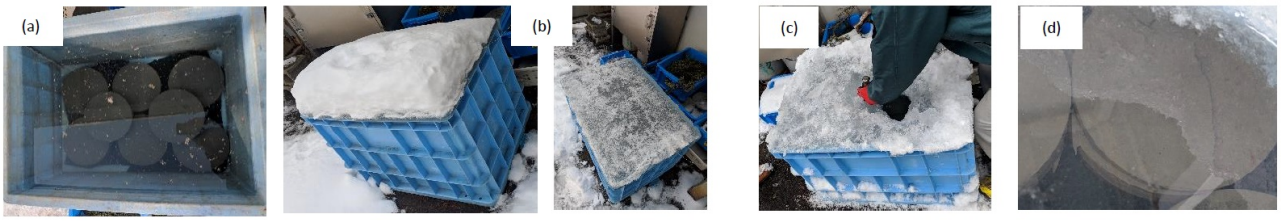

Fig.2 Completely submerged specimen in natural FT conditions

(a) Specimen submerged under 400mm water depth (b) The top layer of water is frozen (c) Breaking the top frozen layer using chisel and hammer to extract the specimen (d) It can be seen that the sample is flaking under water.

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Implications for paleoenvironment and tectonic setting of Khujirt area, Northern Mongolia

*Bat-Orshikh Erdenetsogt[1], Ariunbold Erdene[2]

1. National University of Mongolia, 2. ErdGeo LLC

Khujirt is a syncline that hosts Jurassic coal deposit in Northern Mongolia. Nine coal samples collected from exploration borehole were selected for analyses of major oxide and trace and REE elements of coal ash. The analyses were performed at Central Geological Laboratory in Ulaanbaatar, Mongolia according to appropriate international standards.

The average value of CAI for the samples is 82.8±1.6, reflecting intensive weathering in the source area. The plotted data on A-CN-K diagram displays that rocks in coal were sourced mainly from Early Permian andesite and basalt and Early Paleozoic granodiorite, which borders Khujirt syncline. It is also supported by AlO2O3/TiO2 (avg. 18.4±0.3) and TiO2/Zr (63.4±2.4) ratios. To infer tectonic setting, two multi-dimensional discrimination diagrams were used. The results suggest that the tectonic setting of Khujirt was foreland basin that was probably formed by closure of Mongol-Okhotsk Ocean. This finding is consistent with generally accepted tectonic history of the region. Low Rb/Sr (0.02-0.04) and high Sr/Cu (13.8-30.6) ratios of the studied samples indicate that arid climate condition was dominant during the deposition of Khujirt peat accumulation. This conclusion is supported by C-values of the samples range from 0.1 to 0.3 as well. Due to arid condition, salinity was high reflecting substantially high Sr/Ba ratio varying from 1.7 to 2.7.

Keywords: sedimentology, geochemistry, Mongolia

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Petrographic characteristics of Middle Permian sandstones in Southern Mongolia and their geological implications

*Enkhbayar Bolormaa[1], Dashpuntsag Nansalmaa[1], Bat-Orshikh Erdenetsogt[1], Baigalmaa Norov[1], Bat Bold[1], Luvsanchultem Jargal[1], Avirmed Tulga[1]

1. National Unniversity of Mongolia

Middle Permian Tavantolgoi coal deposit lies in southern Mongolia and has more than 6 billion tons of coal including significant tonnage of coking coal. In 2017, exploration bore holes were drilled at Borteeg, the largest syncline of the deposit. Eighteen sandstone samples were collected from coal-bearing sequences that were intersected by 900 m deep bore holes. Standard thin sections were prepared from core samples and studied under polarizing microscope and point-counted using the Gazzi-Dickinson method.

Detrital grains of the studied samples consist of mineral grains and rock fragments. They are generally well-rounded and moderately sorted. Size of detrital grains ranges from 0.1 mm to 1.0 mm. Detrital minerals quartz and feldspar comprising 7-31% of the total constituents. Quartz comprises 13-24% and monocrystalline quartz dominates over polycrystalline quartz. In feldspar grains, plagioclase is more abundant than K-feldspar. Lithic fragment comprises 49-60%, of which volcanic rock fragments predominates. Cement is carbonates partly enriched in iron oxide, resulting in reddish color.

The sandstones of Middle Permian in Borteeg syncline are classified as litharenite suggesting that weathering intensity in source area was weak, probably due to relatively arid to semiarid climate conditions. Provenance analysis (Q-F-L, Qm-F-Lt, and Qp-Lvm-Lsm diagrams) suggests that the sandstones are recycled sediments derived from transitional arc and undissected arc that were formed during the closure of Paleoasian ocean between southern Mongolia and North China block.

Keywords: sandstone provenance, Middle Permian, Mongolia

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[J] Poster | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_22

[H-CG32] Interdisciplinary approach to earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Naofumi Yamaguchi(Center for Water Environment Studies, Ibaraki University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Hideko Takayanagi(Institute of Geology and Paleontology, Graduate School of Science, Tohoku University)

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Effect of organic matter input on bioturbation in submarine channel-levee deposits: an example of the Izaki Olistolith in the Oligocene Nichinan Group

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This study focused on the variation of bioturbation intensity, ichnodiversity, and total organic carbon contents in actual submarine fan deposits, aiming to clarify their relationships. For sedimentological analysis, effects of sediment reworking by benthic animals have been estimated by indices of bioturbation intensity such as “ichnofabric indices” (*ii*; Droser and Bottjer, 1986) or “bioturbation indices” (BI; Taylor and Gorldring, 1993), which are represented by proportion of bioturbated area in outcrop surface. Recently, it was suggested that number of ichnotaxa (ichnodiversity) varies associated with changes of sedimentary environments, so that differences of ichnodiversity can also be an indicator of sedimentary environments (Buatois and Mángano, 2013; Callow et al., 2014). It is considered that various paleoenvironmental factors may affect the variation of bioturbation intensity or ichnodiversity (Orr, 2001). Particularly, fluctuation of organic matter input can significantly change the activities of benthic animals as shown in studies of biodiversity of recent shallow-marine benthic communities (e.g. Hyland et al., 2005). However, there are a few researches to discuss the relationships between ichnoassemblages and organic matter conditions (e.g. Wetzel and Uchman, 1998).

To this end, we observed the ichnoassemblage of the Izaki Olistolith within the Oligocene Nichinan Group in the southern part of Kyushu Island, southwest Japan. The Izaki Olistolith is composed of the alternating beds of turbidite sandstone and mudstone which are interpreted as deposits of a submarine channel-levee system. The lower part of the Izaki Olistolith consists of the mudstone dominated levee deposits and is overlain by the sandstone dominated channel-fill depoisits. A total of 22 ichnogenera and 24 ichnospecies occurred from the Izaki Olistolith. According to recent quantitative evaluation of ichnodiversity, the ichnodiversity in the channel-fill deposits was 1.74 times higher than that in the levee deposits (Kikuchi et al., 2018). The stratigraphic changes of bioturbation intensity and ichnodiversity were estimated by application of the image-resampling method proposed by Kikuchi et al. (2018). In addition, geochemical analysis was also examined in the Izaki Olistolith. The total organic carbon (TOC) and total nitrogen (TN) contents in 77 mudstone samples were measured with the element analyzer FLASH 2000 (Thermo Fisher Scientific).

Detailed analysis of ichnodiversity for each 1 m thick interval showed that the ichnodiversity in the Izaki Olistolith increased upward associated with paleoenvironmental changes from levee to channel environments and subsequent filling of the channel. In contrast, bioturbation intensity was constantly low, showing no significant trend in vertical changes. The TOC values range from 0.38 to 0.52wt.%. The mean values of TOC and TN were 0.46wt.% and 0.08wt.%, respectively. Both of TOC and TN values slightly increased upward.
The test of correlation suggested a significant positive correlation between the ichnodiversity and the mean of TOC for each 1 m thick interval. This implies that the variation of ichnodiversity in submarine fan deposits can be an indicator of organic matter input, especially under the condition of relatively low amount of input (0.3–0.5wt.%). In future work, it is necessary to analyze the deposits that have higher organic matter contents and investigate how bioturbation intensity and ichnodiversity change under the

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high organic matter input.

Keywords: ichnofossil, ichnodiversity, bioturbation intensity, total organic carbon

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Effect of Freeze-Thaw Cycles on Bank Erosion Rate of Bedrock

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Freeze-Thaw erosion happens when water penetrates through the cracks in rocks; freezes, and expands in volume, making the cracks bigger and eventually the rock weaker. Freeze-Thaw induced erosion accounts for 24% of the world land area and 55% of the total land area of the northern hemisphere making it the third major erosion type after water erosion and wind soil erosion. Even though, the effect of FT is massive, knowledge regarding how it effects rivers is scarce.

In this study, we have made an attempt to explore the change in the rate of erosion followed by a series of Freeze-Thaw cycles. We collected specimens from Rekifune river in Hokkaido, Japan. Each specimen was circular with a diameter of 220mm and height of 50mm. The specimens were immediately kept in air cushions to keep from drying, freezing or shock during transportation. In laboratory, until the test, the specimens were kept at room temperature, completely submerged in water to prevent the specimens from changes in water content.

Specimens were put through freeze-thaw cycle using a Freeze-Thaw Apparatus shown in Fig.1. The minimum temperature maintained to achieve freezing of the specimens was -18℃. The maximum temperature of the apparatus was maintained at 20℃ in order to achieve thawing of specimens. The time taken to achieve minimum and maximum temperatures was 3hours and 4hours respectively. The specimens were maintained at minimum and maximum temperature for 0.5 hours each. The total time taken for an entire cycle of freezing and thawing was 8 hours. After 1 cycle of FT, the surface layer peeled off; After 2nd cycle, the surface started getting flaky and peeling off; After 3rd cycle, a thin surface layer peeled off and the specimen disintegrated and couldn’ t be prepared for another FT cycle. The tensile strength of specimens decreased considerably after first FT cycle itself. The erosion rate of the specimens was measured using a rotation mill. The erosion rate of specimens decreased exponentially as shown in Fig.1. However, these samples were artificially frozen and thawed in a dry condition. In order to study the effect of FT cycles in wet conditions, we performed another set of experiments with specimens completely submerged in water. These specimens were kept outside the laboratory in order to study the effect of FT in natural conditions. The specimens were submerged under 400mm water depth. The top layer of the water was frozen within 1 night of setting up the specimens. After 1 month, the specimen was tested for its erosion rate. The erosion rate of the specimen became 2 times of specimen not put through FT cycle. Moreover, as shown in Fig.2; the specimens were flaking and disintegrating by itself due to FT. These results suggest that FT effects not only river banks, but river bed as well.

Keywords: Freeze-Thaw weathering, erosion rate, bedrock

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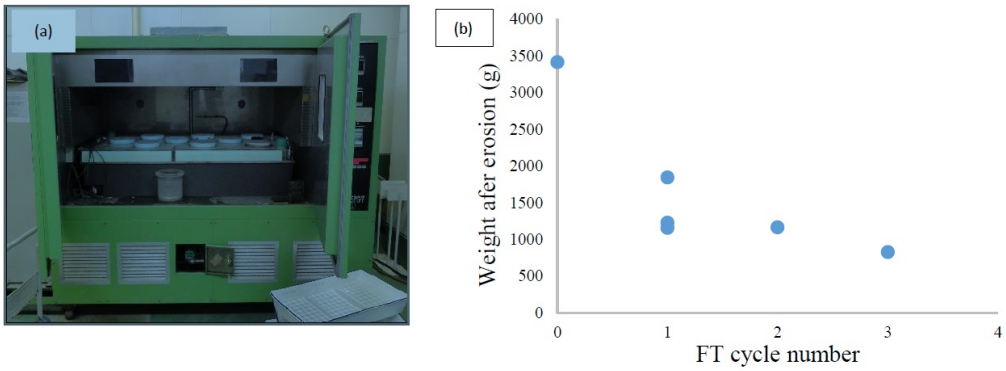

Fig.1 Experiment performed in dry conditions

(a) Apparatus used for mimicking FT cycle (b) Graph showing decrease erosion rate with respect to number of FT cycle.

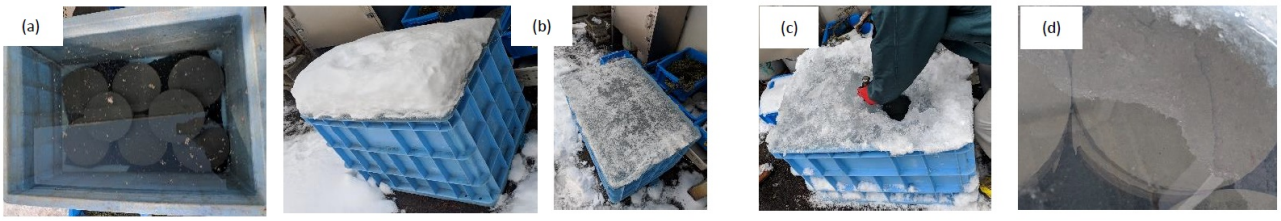

Fig.2 Completely submerged specimen in natural FT conditions

(a) Specimen submerged under 400mm water depth (b) The top layer of water is frozen (c) Breaking the top frozen layer using chisel and hammer to extract the specimen (d) It can be seen that the sample is flaking under water.

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Implications for paleoenvironment and tectonic setting of Khujirt area, Northern Mongolia

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Khujirt is a syncline that hosts Jurassic coal deposit in Northern Mongolia. Nine coal samples collected from exploration borehole were selected for analyses of major oxide and trace and REE elements of coal ash. The analyses were performed at Central Geological Laboratory in Ulaanbaatar, Mongolia according to appropriate international standards.

The average value of CAI for the samples is 82.8±1.6, reflecting intensive weathering in the source area. The plotted data on A-CN-K diagram displays that rocks in coal were sourced mainly from Early Permian andesite and basalt and Early Paleozoic granodiorite, which borders Khujirt syncline. It is also supported by AlO2O3/TiO2 (avg. 18.4±0.3) and TiO2/Zr (63.4±2.4) ratios. To infer tectonic setting, two multi-dimensional discrimination diagrams were used. The results suggest that the tectonic setting of Khujirt was foreland basin that was probably formed by closure of Mongol-Okhotsk Ocean. This finding is consistent with generally accepted tectonic history of the region. Low Rb/Sr (0.02-0.04) and high Sr/Cu (13.8-30.6) ratios of the studied samples indicate that arid climate condition was dominant during the deposition of Khujirt peat accumulation. This conclusion is supported by C-values of the samples range from 0.1 to 0.3 as well. Due to arid condition, salinity was high reflecting substantially high Sr/Ba ratio varying from 1.7 to 2.7.

Keywords: sedimentology, geochemistry, Mongolia

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Petrographic characteristics of Middle Permian sandstones in Southern Mongolia and their geological implications

*Enkhbayar Bolormaa[1], Dashpuntsag Nansalmaa[1], Bat-Orshikh Erdenetsogt[1], Baigalmaa Norov[1], Bat Bold[1], Luvsanchultem Jargal[1], Avirmed Tulga[1]

1. National Unniversity of Mongolia

Middle Permian Tavantolgoi coal deposit lies in southern Mongolia and has more than 6 billion tons of coal including significant tonnage of coking coal. In 2017, exploration bore holes were drilled at Borteeg, the largest syncline of the deposit. Eighteen sandstone samples were collected from coal-bearing sequences that were intersected by 900 m deep bore holes. Standard thin sections were prepared from core samples and studied under polarizing microscope and point-counted using the Gazzi-Dickinson method.

Detrital grains of the studied samples consist of mineral grains and rock fragments. They are generally well-rounded and moderately sorted. Size of detrital grains ranges from 0.1 mm to 1.0 mm. Detrital minerals quartz and feldspar comprising 7-31% of the total constituents. Quartz comprises 13-24% and monocrystalline quartz dominates over polycrystalline quartz. In feldspar grains, plagioclase is more abundant than K-feldspar. Lithic fragment comprises 49-60%, of which volcanic rock fragments predominates. Cement is carbonates partly enriched in iron oxide, resulting in reddish color.

The sandstones of Middle Permian in Borteeg syncline are classified as litharenite suggesting that weathering intensity in source area was weak, probably due to relatively arid to semiarid climate conditions. Provenance analysis (Q-F-L, Qm-F-Lt, and Qp-Lvm-Lsm diagrams) suggests that the sandstones are recycled sediments derived from transitional arc and undissected arc that were formed during the closure of Paleoasian ocean between southern Mongolia and North China block.

Keywords: sandstone provenance, Middle Permian, Mongolia

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[J] Oral | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 105 1F

[H-CG32] Interdisciplinary approach to earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Naofumi Yamaguchi(Center for Water Environment Studies, Ibaraki University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Hideko Takayanagi(Institute of Geology and Paleontology, Graduate School of Science, Tohoku University), Chairperson:Koji Seike

To understand landscape evolution and dynamics of erosion, transport and sedimentation of earth-surface materials, the latest results of multiple research fields including engineering and earth sciences will be presented. As well as any researches of sedimentology and sedimentary petrology, interaction between fluid, sediments and geomorphology is focused. Interdisciplinary discussions of science, disaster prevention and resource exploration will be expected.

1:45 PM - 1:50 PM JST | 4:45 AM - 4:50 AM UTC

Introduction

1:50 PM - 2:20 PM JST | 4:50 AM - 5:20 AM UTC

[HCG32-01] Long-term beach observation and future shoreline prediction

★Invited Papers

*Masayuki Banno[1] (1.Port and Airport Research Institute)

2:20 PM - 2:35 PM JST | 5:20 AM - 5:35 AM UTC

[HCG32-02] Migration of sand waves observed in Okinose area of Osaka Bay

*Kojima Hibiki[1], Tetsuo Matsuno[2,3], Mamoru Sano[2], Nobukazu Seama[3,2], Noritaka Endo[4], Ken'ichi Ohkushi[1], Atsushi Tani[1] (1.Graduate School of Human Development and Environment, Kobe University, 2.Kobe Ocean Bottom Exploration Center(KOBEC), Kobe University, 3.Graduate School of Science / Faculty of Science, Kobe University, 4.School of Geoscience and Civil Engineering College of Science and Engineering, Kanazawa University)

2:35 PM - 2:50 PM JST | 5:35 AM - 5:50 AM UTC

[HCG32-03] Inverse analysis of lobe/gully on Mars: examination by 2D Voellmy fluid model

Kyohei Noumura[1], *Hajime Naruse[1] (1.Department of Geology and Mineralogy, Graduate School of Science, Kyoto University)

2:50 PM - 3:05 PM JST | 5:50 AM - 6:05 AM UTC

[HCG32-04] Development of provenance study using quartz shapes and surface microtextures

*Hiromi Itamiya[1], Ritsuko Sugita[1], Toshihiko Sugai[2] (1.National Research Institute of Police Science, 2.The University of Tokyo)

3:05 PM - 3:15 PM JST | 6:05 AM - 6:15 AM UTC

Discussion

Long-term beach observation and future shoreline prediction

*Masayuki Banno[1]

1. Port and Airport Research Institute

Port and Airport Research Institute (PARI) has measured daily beach profiles since 1986 at the Hasaki coast of Japan. This long-term and high-time-resolution beach profile data is used to understand the nearshore processes and predict the future beach morphological change. The talk will be about the long-term beach observation data and the future projection of the shoreline change in response to SLR and wave climate change under global climate change. Long-term beach observation data available at the other beaches will also be introduced.

Keywords: Shoreline change, Beach morphology

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Migration of sand waves observed in Okinose area of Osaka Bay

*Kojima Hibiki[1], Tetsuo Matsuno[2,3], Mamoru Sano[2], Nobukazu Seama[3,2], Noritaka Endo[4], Ken'ichi Ohkushi[1], Atsushi Tani[1]

1. Graduate School of Human Development and Environment, Kobe University, 2. Kobe Ocean Bottom Exploration Center(KOBEC), Kobe University, 3. Graduate School of Science / Faculty of Science, Kobe University, 4. School of Geoscience and Civil Engineering College of Science and Engineering, Kanazawa University

A micro-topography formed on unconsolidated sand particles by water flow with wavelengths from a few meters to several hundreds of meters is called sand waves. On the seabed (water depth between 30-45 m) in Okinose, eastern margin of Awaji Island in Osaka Bay, Japan, sand waves of a range of wavelengths between 10-100 m are observed. In this area, there is a constant flow called Okinose Return Current. Although it is important to elucidate the detailed characteristics, formation mechanism, and migration mechanism of the sand waves in Okinose due to the viewpoint of protection of marine resources and ocean navigation security, they have not been well studied (Yashima, 1992). Therefore, we investigated sand waves on the seabed in Okinose six times in about a year to reveal which direction and how long the sand waves migrate in this period.

We investigated the bathymetry of Okinose using the Multi-Narrow Beam Echo Sounder (MBES) mounted on FUKAE MARU (Kobe University, Graduate School of Maritime Sciences). In addition, seabed samples were obtained using a grab type mud sampler. Dates of the observation were September 27 and November 12 in 2017, and March 24, August 31, September 26, and October 13 in 2018. Survey area was south-north 2 km and east-west 1 km.

Analysis of the bathymetry revealed the sand waves with different wavelengths in southeast Okinose. Following the criteria given by Perillo and Ludwick (1984), sand waves were classified into three types by the wavelengths and the wave heights; large sand waves (wavelengths more than 50 m, wave heights more than 2 m), small sand waves (wavelengths between 10-50 m, wave heights between 0.6-2 m), and megaripples (wavelengths less than 10 m, wave heights less than 0.6 m). In these observations, large sand waves did not move, whereas small sand waves migrated 5 m to the north and megaripples would change every day. Since sand waves usually migrate to the direction of the residual current (Nemeth et al., 2002), our observation of the small sand waves is consistent. In addition, despite three natural disasters of the Osaka Northern Earthquake on June 18, 2018 and two typhoons No.20 on August 23 and No.21 on September 4 both in 2018, large sand waves were not changed obviously.

The structured sand waves have been reported (e.g. Osumi Strait in southern Kyushu, Japan (Ikehara, 1998) and Cadiz Bay in Spain (Nemeth et al., 2007)). Our investigation revealed that the sand waves in Okinose were also structured and classified into three types. Generally, wavelengths and wave heights of sand waves are determined by water depth, particle size of the sediment, and sea flow above the seabed. Therefore, it is important to evaluate the sea flow over the sand waves to understand their formation and migration mechanisms. In the next step, we have a plan to simulate the flow above the seabed of Okinose to approach the formation and migration mechanisms of Okinose sand waves.

Keywords: sand wave, Osaka Bay, migration

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Inverse analysis of lobe/gully on Mars: examination by 2D Voellmy fluid model

Kyohei Noumura[1], *Hajime Naruse[1]

1. Department of Geology and Mineralogy, Graduate School of Science, Kyoto University

It has been known lobate deposits accompanied with small gullies distribute on the surface of Mars, but their origin has not been clarified yet. Topographic features of lobate deposits on Mars resemble deposits of debris flow on Earth, which is a flow composed of high-concentration and fluid (water). Therefore, lobate deposits have been focused as proxies of fluid phase of water on Martian surface environments. However, several studies suggested that lobate landform can also be formed by other processes such as rock avalanches, and thus water in fluid phase may not be required for producing such deposits. Thus, the controversy on existence of fluid water has not been settled. To this end, this study aims to distinguish the formation process of lobes on Mars by inverse analysis of rheological properties of the flow. Two dimensional Voellmy fluid model was employed as the forward model, which has been proved to be capable of reproducing behavior of debris flows or snow avalanches on Earth. Istok Crater that locates in mid latitudes of the southern Hemisphere of Mars was chosen as the study area. Geomorphology of a lobate deposit on the northern fringe of the crater was measured from DEM, and the rheological parameters of the flow was reconstructed by parametric optimization of the forward model to fit the calculation results to actual geomorphology. As a result, the inverse analysis suggested that the rheological property of the formative process of the lobate deposit was quite different from terrestrial debris flows estimated on Earth. Also, the reconstructed parameters largely deviated from other known processes such as rock or snow avalanches. This may imply that the unknown processes such as avalanches of CO2 frost that does not exist on Earth should be supposed as the formation process of lobes.

Keywords: Mars, debris flow, gully

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Development of provenance study using quartz shapes and surface microtextures

*Hiromi Itamiya[1], Ritsuko Sugita[1], Toshihiko Sugai[2]

1. National Research Institute of Police Science, 2. The University of Tokyo

[Introduction]
Quartz is highly resistant to weathering and various surface microtextures are formed and preserved on grains. The microtexture of a quartz surface (MQS) reflects the sedimentary history of the grain, including its parent rock, transportation process, and depositional environment. The relationship between MQS and sedimentary history has been investigated by using scanning electron microscopy (SEM) (Krinsley et al. 1973; Mahaney, 2002). The types and frequency of microtexture may be different from previous studies in foreign countries because MQS relates to the geological and geomorphological settings at sampling sites. However, surface textural analysis has primarily been used to estimate fault activity, and the variation in MQS have not been studied aiming to the provenance study in Japan. In this study, we observed the quartz grains of Japan to reveal the relationship between quartz morphological features and sedimentary history. In addition to the SEM observation, the image analysis and statistics analysis were applied.

[Sampling and methods]
Nineteen fluvial sediments and nineteen coastal sands were collected in Japan. Carbonates, iron oxides and organic matters were removed from samples by chemicals and quartz grains (0.1 to 1 mm) were randomly handpicked under a stereomicroscope. After coating with a layer of platinum, twenty quartz grains for each sample were observed by SEM. Quartz shape was estimated by roundness (Takashimizu et al. 2016) and fractal dimension (Suzuki et al. 2013) using SEM images and ImageJ. A total of fifteen MQS was observed with reference to the previous study (Vos et al. 2014). The number of grains possessing each microstructure was counted in every sample. Their frequency distributions were applied to the principal component analysis (PCA) using statistical software.

[Result and Discussion]
Fluvial grains showed angular outline, high relief and large number of conchoidal fractures, which were probably produced by a powerful impact or pressure on the grain surface (Vos et al. 2014). Small hole of less than 10 μm can be observed on some samples. It derived from small inclusions, and its frequency may show the differences of parent rocks of samples.
Most of the quartz in seacoast are characterized by rounded outline and medium to low relief. On the surface, there are many v-shaped percussion cracks, which are produced by grain-to-grain collision in subaqueous environment (Krinsley et al. 1973). Some coastal samples had angular outline and many conchoidal fractures like fluvial sediments, but v-shaped percussion cracks are scarcely observed. It may be because grains of these coastal areas were supplied by steep rivers near sampling site. It means quartz shapes and surface microtextures of beach sands relate to the sediment supply.
Frequency distribution of MQS was applied to the PCA, and samples collected from the same area could be grouped in PCA scores plot. The first principal component (PC1) was explained by chemically formed microtextures and the second principal component (PC2) was explained by mechanically ones. PCA is effective method to grouping the samples under similar sedimentary history.
It is revealed that the morphological diversity of quartz grains can be observed, even in areas with complex geological and geomorphological settings such as Japan. The types of MQS were similar to the

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previous studies in foreign lands, but some types were sparsely observed compared to the previous report. MQS reflect parent rock, transportation systems and depositional environment, so it is important to comprehensively discuss the result of quartz analysis referring to the natural environment of sampling area.

(Krinsley et al, Cambridge University Press, 1973: Mahaney, Oxford University Press, 2002: Takashimizu et al. Prog. Earth Planet Sci., 2016, 3:2: Suzuki et al, J. Geol. Soc. Japan, 2013, 119(3), 205-216: Vos et al. Earth-Science Reviews, 128(0), 93-104)

Keywords: Quartz, SEM, Image analysis, Surface microtexture, Fractal dimension

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[J] Oral | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 105 1F

[H-CG32] Interdisciplinary approach to earth surface processes related to deposition, erosion and sediment transport

convener:Koji Seike(Geological Survey of Japan, AIST), Naofumi Yamaguchi(Center for Water Environment Studies, Ibaraki University), Hajime Naruse(Department of Geology and Mineralogy, Graduate School of Science, Kyoto University), Hideko Takayanagi(Institute of Geology and Paleontology, Graduate School of Science, Tohoku University), Chairperson:Hideko Takayanagi(Tohoku University), Koji Seike

To understand landscape evolution and dynamics of erosion, transport and sedimentation of earth-surface materials, the latest results of multiple research fields including engineering and earth sciences will be presented. As well as any researches of sedimentology and sedimentary petrology, interaction between fluid, sediments and geomorphology is focused. Interdisciplinary discussions of science, disaster prevention and resource exploration will be expected.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[HCG32-05] Detrital heavy mineral record and Nd-Sr isotopic signature in Bengal Fan

*Kohki Yoshida[1], Cruz Jarrett[2], Manoj M.C.[3], Nozomi Hatano[5], Christian France-Lanord[4], Takeshi Kuritani[6] (1.Department of Geology, Faculty of Science, Shinshu University, 2.Florida State University, 3.Birbal Sahni Institute of Palaeosciences, 4.CNRS- Universite de Lorraine, 5.Graduate School of Science and Technology, Shinshu University, 6.Hokkaido University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[HCG32-06] Evaluation of plant-fragment concentration mechanism in the turbiditic sediments in the Bouma Sequence by biomarker analysis in the Kawabata Formation, Yubari area, central Hokkaido, Japan.

*Hiroyasu Asahi[1], Satoshi Furota[2], Ken Sawada[3] (1.Graduate School of Science, Hokkaido University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[HCG32-07] Tectonic behavior of a forearc basin reconstructed using turbidites: an example from the Plio-Pleistocene Kakegawa Group, central Japan

*Sone Haruki[1] (1.Graduate school of Shimane University, Natural Science and Technology, Major in Science of Environmental systems, Geoscience corse)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[HCG32-08] Most benthos floats up in liquefied sandy substrates: quantitative evaluation by measuring living-organism density

*Koji Seike[1], Shinji Sasa[2], Kotaro Shirai[3], Kaoru Kubota[4] (1.Geological Survey of Japan, AIST, 2.Port and Airport Research Institute, 3.AORI, The University of Tokyo, 4.Kochi Institute for Core Sample Research, JAMSTEC)

4:30 PM - 5:00 PM JST | 7:30 AM - 8:00 AM UTC

Discussion

Detrital heavy mineral record and Nd-Sr isotopic signature in Bengal Fan

*Kohki Yoshida[1], Cruz Jarrett[2], Manoj M.C.[3], Nozomi Hatano[5], Christian France-Lanord[4], Takeshi Kuritani[6]

1. Department of Geology, Faculty of Science, Shinshu University, 2. Florida State University, 3. Birbal Sahni Institute of Palaeosciences, 4. CNRS- Universite de Lorraine, 5. Graduate School of Science and Technology, Shinshu University, 6. Hokkaido University

The Bengal fan was formed by detritus shed by the Ganges and Brahmaputra rivers, reflecting India-Asia plate collision. The “IODP Expedition 354: Bengal Fan” recovered sediments recording the tectonic and climatic history related to the Himalayan orogeny (Fance-Lanord et al., 2016). We examined the heavy mineral assemblage, chemical composition of specific minerals and Nd-Sr isotope in the sediments deposited from the Miocene to present in the deepest hole (U1451A and B) in this expedition to clarify the detailed denudation history of the Himalayas. In addition, the heavy minerals in modern river sediments, taken from the Ganges and the Brahmaputra River in eastern India, are examined to compare with the Bengal Fan sediments.

The basal horizon of the Bengal Fan sediments, which consists of the latest Oligocene to earliest Miocene, was supplied by high-grade metamorphic terrene, correlatable to the High Himalaya Crystalline (HHC). Also, mafic metamorphic detritus, such as blue-green amphibole, were supplied suddenly from 14-13 Ma. Rare chromian spinels and Na-amphiboles were found in several horizons. These mafic detritus were actively provided after 7 Ma. These detritus were probably provided from the Yarlung-Tsangpo Suture Zone (YTSZ). After 6 Ma, olivine-pyroxene rich horizons are frequently intercalated in the Quaternary series. Tentative dominance of specific metamorphic minerals suggests episodic sediment production around HHC and YTSZ. The predominance of mafic minerals after 6 Ma indicates the contribution of the Brahmaputra River was increased. It is reported that the bed load sediments in the upper stream of the Brahmaputra River are characterized by the predominance of olivine, pyroxene, and ilmenite with a minor amount of spinels (Garzanti et al., 2004).

The depth profile of Sr-Nd isotopic signatures in the Bengal Fan sediments shows significant temporal variations. The range in 87Sr/86Sr and ε Nd indicate the dominance of Himalayan source. These signatures are bracketed by sediments from the Ganges, Brahmaputra River sands overlap with a data of the Lower Meghna (Pierson-Wickmann et al., 2001) indicating that the sediments in Bengal Fan are mixed products supplied from these two big rivers. Also, the Sr-Nd isotope depth profiles show a change in isotopic compositions around the lower part of the Middle Miocene.

These mineralogical and isotopic signatures indicate a relatively reduced supply of sediments from Brahmaputra river during the early Miocene time. The Sr-Nd isotopic signatures, the occurrence of mafic minerals and rare chromite grains also show significant variations indicating changes in the relative proportion of sediments originated from two big rivers. Especially in Pliocene and Quaternary sequences, the heavy mineral assemblage and Sr-Nd isotope signatures display a rapid and frequent change in the relative portion of sediments from both revivers. This is possibly related to the historical change of Brahmaputra river discharge refracting river capturing in eastern Himalayan syntaxis.

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Keywords: Himalaya, collision mountains, Miocene

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Evaluation of plant-fragment concentration mechanism in the turbiditic sediments in the Bouma Sequence by biomarker analysis in the Kawabata Formation, Yubari area, central Hokkaido, Japan.

*Hiroyasu Asahi[1], Satoshi Furota[2], Ken Sawada[3]

1. Graduate School of Science, Hokkaido University, 2. Japan Agency for Marine-Earth Science and Technology, 3. Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University

Kawabata Formation distributed in Yubari area, central Hokkaido, is formed by basin-filled and slope-apron turbidite systems, and sandstone and mudstone are mainly predominated as turbiditic sequence. Distinctive plant-fragment concentrated sandstones were found in the Kawabata Formation, and their sedimentological and biomarker analyses suggested that these sediments were deposited by hyperpycnal flow (Furota et al., 2014). However, such thin layer concentrated plant fragments are also formed in the typical turbidite characterized as the Bouma sequence. In the present study, we conducted biomarker analysis of sandstone and mudstone characterized as the Bouma sequence from the Kawabata Formation to evaluate sedimentological processes and to compare plant-fragment concentrated sandstones in hyperpycnite.

The sandstones and mudstones analyzed were collected from the route of the Soumokumai-zawa River, Yubari, central Hokkaido, during 2017. For the biomarker analysis, lipids were extracted with dichloromethane/methanol, and separated to aliphatic, aromatic and polar fractions. These lipids were identified and quantified by GC-MS and GC-FID.

The turbiditic sequence analyzed is about 15cm thick, and corresponds to the Bouma sequence, but no containing Td unit. Sedimentary layer equivalent to Ta units consists of medium-fine sands with tiny black plant-fragments. Tb unit consists of fine sands with parallel laminations containing the concentrated plant fragments. Tc unit also consists of fine sands about 1-2cm thick without cross laminations, and the concentrated plant fragments are observed as many black bands in this unit. Te unit is massive sediment that consists of very fine sands to silty muds without plant fragments.

Concentrations of *n*-alkane in the turbiditic sequence are the minimal values in the Ta units. The concetrations increase in Tb and Tc, and then decrease in Te units. This trend is also shown in variations in the concentrations of plant-derived terpenoids. Pristane/Phytane ratios are the highest value (ca. 5) in Tb and Tc units, indicating much higher contribution of terrestrial plant-derived particles in these sedimentary phases. The ratios of C27/C29 sterane, which are indicators of marine / terrigenous material ratios as source of organic matter, tend to decrease from Ta to Tc units, and are especially about 0 at Tc unit. On the other hand, the C27/C29 sterane ratio of the Te unit shows the highest value in the turbiditic sequence. These results imply that terrigenous components were separated and concentrated in specific layers by turbidity flow, which differs from continuous transport of terrigenous organic matter by hyperpycnal flow. Triterpenoids and diterpenoids are useful as angiosperm and gymnosperm (conifer) biomarkers, respectively. The diterpenoid compositions and HPP, which is an indicator of coniferous vegetation, are hardly changed throughout Ta to Te units. Triterpenoid compositions are also almost constant within the turbiditic sequence. These results suggest that the terrigenous materials were homogenized in sediments during transporting and reworking by turbidity current. In addition, A-ring degraded triterpenoid (des-A triterpenoids) were detected as major components in all sediment units. The

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des-A triterpenoids are thought to be generated by microbial degradation during early diagenesis. The des-A triterpenoid compositions are also nearly constant as the results of diterpenoids and non-degraded triterpenoids. However, the ratios of des-A triterpenoid/pentacyclic (non-degraded) triterpenoid are higher throughout the turbiditic sequence, especially Tb and Tc units. Furota et al. (2014) reported that the des-A/pentacyclic triterpenoid ratios in sandstone units were clearly lower than mudstone units in the hyperpycnite, suggesting that more fresh terrigenous organic matter is rapidly transported by the hyperpycnal flow. On the other hand, our results imply that terrigenous matter is not rapidly deposited and reworked by turbidity current forming a typical Bouma sequence, and might be diagenetically altered in these processes. Thus, it is suggested that organic geochemical features are clearly different between the hyperpycnal and typical turbidity flows, and the hyperpycnal flow system occurs the effective transport and deposition of fresh terrigenous organic matter compared to those by turbidity current.

Keywords: Turbidite, Biomarker, Hokkaido

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Tectonic behavior of a forearc basin reconstructed using turbidites: an example from the Plio-Pleistocene Kakegawa Group, central Japan

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The present study reconstructed the tectonic behavior of a forearc basin using the characteristics of turbidites. Topographic obstacles within a basin affects on the pathway of a turbidity current, causing the flow reflection or deflection within the basin. Turbidites recording flow reflections by outer rim of a forearc basin have been reported from the middle part of the Plio-Pleistocene Kakegawa Group, distributed in western Shizuoka, central Japan. Previous studies reconstructed basin geometry using reflected turbidites using the following concepts: (1) a turbidite sand bed tends to be thicker at the foot of slope where turbidity currents are locally stagnated. Thus the lateral thickness variation of a turbidite sand bed provides the location of foot of slope(s) within the basin. (2) A mud bed covering a turbidite bed becomes thickest at the basin center. The basin geometry reconstructions in the several horizons in the middle Kakegawa Group revealed the shift of the basin center and basin width through time. This methodology needs to be applied for the lower Kakegawa Group in order to understand the tectonic evolution of the basin. The present study described the turbidite beds in the lower part of the group and measured paleoflow and paleoslope directions from the ripple cross-lamination and inclined axis of small slump folds in order to reconstruct the behavior of the early phase of the Kakegawa Forearc Basin.

The lower Kakeagwa Group consists of alternations of sand and mud beds. The turbidite beds in the middle group are made up of fine-grained to very-fine-grained sand and show the characteristics of reflected turbidite without distinct massive division. The turbidites in the lower part, however, show the characteristics different from those in the middle part: they have a massive division with a coarse-grained to very-coarse-grained basal part, and thinner parallel and cross laminated divisions, showing the features of proximal turbidite. Some turbidites host wavy lamination, showing convex-up geometry, which is interpreted as the internal structure of antidunes. The top of the underlying mud beds are locally missing, where the overlying sand bed decomes thicker, and there are local mud clasts beds within the mud bed in some locations: these characteristics are interpreted as having been associated with a small-scale submarine slide. The dominant flow directions range from the east to the south, indicating offshore-ward flows. The division deposited from a reflected current is thinner than that in the middle part, and is not found in some turbidites: the turbidite beds in the lower part are thus interpreted as having been deposited mostly from obverse turbidity currents and having deposited on a slope environment dipping toward the offshore. The studied part of the lower group was resulted from the progradation of sediments from the north, and the basin center appears to have been located further offshore than that in the middle part of the group. Our turbidite observation resulted that there is a minor changes in frequency of reflected turbidites in the measured successions. For knowing the reason for such changes, we need more description of the turbidites in the distal area. As one of the possible reasons, the variation in uplift rate of the outer rim of the basin could be considered.

Keywords: Kakegawa Group, turbidite, forearc basin

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Most benthos floats up in liquefied sandy substrates: quantitative evaluation by measuring living-organism density

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1. Geological Survey of Japan, AIST, 2. Port and Airport Research Institute, 3. AORI, The University of Tokyo, 4. Kochi Institute for Core Sample Research, JAMSTEC

Seabed liquefaction substantially affects benthic ecosystems. To investigate exogenous-forced behavior of organisms in liquefied substrates, we measured the body density of benthic organisms including bivalves, gastropods, annelids, and echinoderms collected from some localities in Japan, and compared them with the liquefied substrate density. Density of most measured benthic species showed was less than that of the liquefied seafloor sediments, suggesting that these species would float upwards in liquefied substrates. In contrast, a few individuals of three species showed higher body densities than the density of the liquefied sediments. These heavier benthic species would be expected to move downward during liquefaction of the substrate. These findings indicate that body density may determine the response of each benthic species to seabed liquefaction, forcing them to move upward or downward depending on their body density.

Keywords: liquefaction, sediment, earthquake, benthos

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[J] Poster | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_6

[H-CG33] Useful life-support systems in closed bio-ecosystems

convener:Kaori Tomita-Yokotani(Faculty of Life and Environmental Sciences University of Tsukuba), Masanori Shinohara(Teikyo University of Science), Shunta Kimura(Graduate School of Life and Environmental Sciences, University of Tsukuba)

In this session, since 2011, we and invited researchers have been introducing and discussing about practical and useful life-support systems in closed bio-ecosystems for inhabitation on extraterrestrial environments. Not only biological studies but also engineering ones including broad research fields are our target. And also, we assume that it is indispensable to discuss about these interdisciplinary fields beyond the generation for inheriting to our next generation and for developing our field. Theme from old and basic to current and applicative from senior to youth including undergraduate are welcomed.

[HCG33-P01] The important matter of food production for long term habitation in extraterrestrial environments

*Kaori Tomita-Yokotani[1] (1.Faculty of Life and Environmental Sciences University of Tsukuba)

[HCG33-P02] Functional evaluation of extracellular polymer substance (EPS) produced by cyanobacterium *Arthrospira platensis*

*Satoru Watanabe[1], Takumi Iwasaki[1], Yutaka Sakamaki[1], Yu Kanesaki[2], Masayuki Ohmori[3] (1.Dept. of Biosci., Tokyo Univ. of Agric., 2.RIGST, Shizuoka Univ., 3.Tokyo Univ.)

[HCG33-P03] The uniqueness of the dry heat tolerance of akinetes of terrestrial cyanobacterium *Nostoc* sp. HK-01

*Shunta Kimura[1,2,3], Kaori Tomita-Yokotani[3] (1.Graduate School of Agricultural and Life Sciences, The University of Tokyo, 2.Japan Society for the Promotion of Science, 3.Faculty of Life and Environmental Sciences, University of Tsukuba)

[HCG33-P04] Potential application of cyanobacteria estimated by gene analysis of terrestrial cyanobacterium, *Nostoc* sp. HK-01, in closed-environment

*Hiroshi Katoh[1], Shunta Kimura[2,3], Kaori Tomita-Yokotani[2] (1.Mie University, 2.University of Tsukuba, 3.The University of Tokyo)

[HCG33-P05] Analysis of macromolecular substances involved in the process of dehydration in a terrestrial cyanobacterium, *Nostoc* sp. HK-01.

*Tomoko Abe[1], Yuka Takazawa[1], Ryusuke Honda[1], Kouga Ichikawa[1], Natsumi Yoshida[1], Shunta Kimura[2,4], Hiroshi Katoh[3], Kaori Tomita-Yokotani[2] (1.School of Science and Engineering, Tokyo Denki University, 2.Faculty of Life and Environmental Sciences, University of Tsukuba, 3.Mie University, 4.Graduate School of Agricultural and Life Sciences, The University of Tokyo)

The important matter of food production for long term habitation in extraterrestrial environments

*Kaori Tomita-Yokotani[1]

1. Faculty of Life and Environmental Sciences University of Tsukuba

The circulation of food in closed environments will be important for achieving long-term habitation in extraterrestrial environments. Production of effective chemicals in crops grown under extraterrestrial environments would be very different from grown on Earth. We will discuss the possibility of local production and consumption of crops in extraterrestrial environments.

Keywords: closed bio-ecosystems, extraterrestrial environments, Food production

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Functional evaluation of extracellular polymer substance (EPS) produced by cyanobacterium *Arthrospira platensis*

*Satoru Watanabe[1], Takumi Iwasaki[1], Yutaka Sakamaki[1], Yu Kanesaki[2], Masayuki Ohmori[3]

1. Dept. of Biosci., Tokyo Univ. of Agric., 2. RIGST, Shizuoka Univ., 3. Tokyo Univ.

Cyanobacteria, which manifest oxygen-producing photosynthesis similar to plants, lives in various environments and contributes greatly to maintenance of the global environment. The *Arthrosphira platensis*(commonly known as spirulina) isolated from Chad Lake in Africa has been used as a health food and pigment material. Since spirulina favors high-salt alkalophilic condition, it can be easily cultured in open system.

Extracellular polymeric substances (EPS), secreted from microorganisms, is mainly composed of polysaccharides and proteins. EPS has a role of protecting cells from environmental stress. In addition, EPS attracts attention in the materials industry, because it shows high-viscosity and water retention. Especially, EPS produced by spirulina is called spirulan. Spirulan has been shown to have health functionalities for humans, such as immunomodulatory activity, however there are many unclear points concerning the molecular mechanism of spirulan production.

We have found that spirulina promotes EPS production under the continuous high-light condition. We analyzed the mechanism of the EPS production. pH of the culture increased under the high-light condition with the consumption of bicarbonate from medium. Transcriptome analysis revealed the up-regulation of photosynthetic genes in the high-light condition and they decreased in the long-term cultivation under the high-light. These results indicate that spirulina synthesizes a large amount of sugar and metabolites to consume excess reducing power generated by continuous high-light stress condition. Those are exported and aggregated as EPS. We also analyzed the metabolites in spirulina EPS using CE-TOF-MS. Comparing to the spirulina powder, the amount of the amino acids, nucleic acids significantly increased in EPS, suggesting that spirulina EPS is more valuable as a nutrient source.

Keywords: Cyanobacteria, Spirulina, Extracellular Polymeric Substances

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The uniqueness of the dry heat tolerance of akinetes of terrestrial cyanobacterium *Nostoc* sp. HK-01

*Shunta Kimura[1,2,3], Kaori Tomita-Yokotani[3]

1. Graduate School of Agricultural and Life Sciences, The University of Tokyo, 2. Japan Society for the Promotion of Science, 3. Faculty of Life and Environmental Sciences, University of Tsukuba

Terrestrial cyanobacteria are useful for enabling bio-chemical circulation in closed bio-ecosystems, which is achieved though their photosynthetic ability, nitrogen fixing ability and utility as a food. Dried colonies of the terrestrial cyanobacterium *Nostoc* sp. HK-01 have a high tolerance to vacuum, UV, gamma-rays, heavy particle beams, and extreme temperatures. Tolerance to extraterrestrial environments is important for transportation in space. *Nostoc* sp. HK-01 was adopted as a biological material for space exposure experiments (“TANPOPO” mission), because of their high environmental tolerances. *Nostoc* sp. HK-01 has several different types of cells in its life cycle. We have revealed that the akinete (dormant cell) cell type of *Nostoc* sp. HK-01 shows tolerance to dry heat. In this study, we tested the dry heat tolerances of cyanobacterial akinetes of several species. We will discuss the uniqueness of the dry heat tolerance of *Nostoc* sp. HK-01.

Keywords: Akinete, Dry heat tolerance, Nostoc sp. HK-01, Terrestrial cyanobacteria

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Potential application of cyanobacteria estimated by gene analysis of terrestrial cyanobacterium, *Nostoc* sp. HK-01, in closed-environment

*Hiroshi Katoh[1], Shunta Kimura[2,3], Kaori Tomita-Yokotani[2]

1. Mie University, 2. University of Tsukuba, 3. The University of Tokyo

Cyanobacteria are photoautotrophic organisms and living various environments on the earth. We have been studying space environment tolerance on drought-tolerant cyanobacterium, *Nostoc* sp. HK-01 (NIES-2109, hereafter HK-01). To live under extreme environments for a long time, HK-01 may change gene expression. Here, we closely check genes for extreme environments tolerance in HK-01 whole genome and will show a part of our new results and discussion. We will also discuss potential application of the cyanobacterium in closed ecosystem.

Keywords: cyanobacteria, gene, closed ecosystem

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Analysis of macromolecular substances involved in the process of dehydration in a terrestrial cyanobacterium, *Nostoc* sp. HK-01.

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1. School of Science and Engineering, Tokyo Denki University, 2. Faculty of Life and Environmental Sciences, University of Tsukuba, 3. Mie University, 4. Graduate School of Agricultural and Life Sciences, The University of Tokyo

*Nosto*c sp. HK-01 is one of terrestrial cyanobacterium having a tolerance to desiccation stress and it has ability of usefulness as a food. It is thought that *Nosto*c sp. HK-01 can be used for bio-chemical circulation in a closed ecosystem, including space. Here, we aim at exploring macromolecular substances that would play an important role in the desiccation stress response.

In this study, to detect intracellular proteins of *Nostoc* sp. HK-01 during dehydration, proteins extracted from the cells on the way the dehydration were applied to SDS-polyacrylamide gel electrophoresis, initially. In the course of dehydration of the cells, the expression level of some proteins changed. Some of them were insoluble proteins, and others were soluble proteins. These proteins could be involved in desiccation tolerance of *Nostoc* sp. HK-01.

Keywords: cyanobacteria, desiccation tolerance, stress protein

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[J] Poster | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_23

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[HCG33-P01] The important matter of food production for long term habitation in extraterrestrial environments

*Kaori Tomita-Yokotani[1] (1.Faculty of Life and Environmental Sciences University of Tsukuba)

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*Satoru Watanabe[1], Takumi Iwasaki[1], Yutaka Sakamaki[1], Yu Kanesaki[2], Masayuki Ohmori[3] (1.Dept. of Biosci., Tokyo Univ. of Agric., 2.RIGST, Shizuoka Univ., 3.Tokyo Univ.)

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[J] Oral | H (Human Geosciences)：H-CG Complex & General

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 202 2F

[H-CG33] Useful life-support systems in closed bio-ecosystems

convener:Kaori Tomita-Yokotani(Faculty of Life and Environmental Sciences University of Tsukuba), Masanori Shinohara(Teikyo University of Science), Shunta Kimura(Graduate School of Life and Environmental Sciences, University of Tsukuba), Chairperson:Shunta Kimura

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3:30 PM - 3:32 PM JST | 6:30 AM - 6:32 AM UTC

Introduction

3:32 PM - 3:47 PM JST | 6:32 AM - 6:47 AM UTC

[HCG33-01] Closed bio-ecosystems in extraterrestrial environments-Research in closed bio-ecosystems

*Kaori Tomita-Yokotani[1] (1.Faculty of Life and Environmental Sciences University of Tsukuba)

3:47 PM - 4:07 PM JST | 6:47 AM - 7:07 AM UTC

[HCG33-02] Concept and Studies of Aquaculture in Space -In the Past and Future-

★Invited Papers

*Masato Endo[1] (1.Tokyo University of Marine Science and Technology)

4:07 PM - 4:27 PM JST | 7:07 AM - 7:27 AM UTC

[HCG33-03] Protection effects of gasotransmitters against oxidation damager in vascular endothelial cells

★Invited Papers

*Shigeki Yoshida[1] (1.University of Tsukuba)

4:27 PM - 4:42 PM JST | 7:27 AM - 7:42 AM UTC

[HCG33-04] Study on nutrition intake and food selection to maintain health for habitation in space

*Yasuko Kimura[1], Shunta Kimura[2,3], Hiroshi Katoh[4], Kaori Tomita-Yokotani[2] (1.Jumonji University, 2.University of Tsukuba, 3.The University of Tokyo, 4.Mie University)

4:42 PM - 4:57 PM JST | 7:42 AM - 7:57 AM UTC

[HCG33-05] Limit of "rational optimism", Earth as CELSS, and sustainability of human-being

*Masanori Shinohara[1] (1.Teikyo University of Science)

4:57 PM - 5:00 PM JST | 7:57 AM - 8:00 AM UTC

Discussion

Closed bio-ecosystems in extraterrestrial environments-Research in closed bio-ecosystems

*Kaori Tomita-Yokotani[1]

1. Faculty of Life and Environmental Sciences University of Tsukuba

Researchers in this session have been studying useful life-support systems in closed bio-ecosystems since 2011. The final goal of our studies is to inhabit in extraterrestrial environments. There are various field of research related to biological and technical systems in closed systems. We have to have discussions with the researchers from a wide range of ages because our results will be inherited by the next generation. Here, I will introduce our session’ s outline and the contents of individual presentation. This year, we will focus on food for humans. The results of our discussions will contribute to our goal.

Keywords: closed bio-ecosystems, extraterrestrial environments, food

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Concept and Studies of Aquaculture in Space -In the Past and Future-

*Masato Endo[1]

1. Tokyo University of Marine Science and Technology

Aquaculture as a food production subsystem of closed ecological human habitat in space was advocated to provide animal protein especially, various examinations related with it have been proceeded by our studies for 20 years. In actual, the scientific knowledge of response in aquatic animals under gravity changing in space environment and fish production with material circulation has been accumulated. These results show the possibility of aquaculture in space, that will be the necessary basic data to realize a human life under space environment in the future. The concept and the studies of aquaculture in space have been focused on the production technology so far. Regarding improvement of the productivity, the introduction of automatic fish rearing and plankton culture system that has been developed at the ground level will be required. Apart from that, the consideration of material flow in the whole space habitat, and post-harvest technology will be needed. The comprehensive deliberations including other subsystem about the material and energy flows will be required, the study will be needed to conduct the various simulations with mathematical models made from the accumulated basic data of modules and subsystems constituting human space habitat. The preservation of products will be also required as the buffer of material circulation, therefore the applications of freezer storage, canned food and retort food production are necessary. Diversity of food consumption and artificial ecosystem considering the demands and limitations should be eventually investigated for good human life of space habitation. Various requirements and limitations occur to the construction of material flows in the artificial ecosystem, chose of produced species, and selection of the cooking methods. The preparation of their options is essential in consideration of the requirements and limitations for the whole facility of human space habitat.

Keywords: Aquaculture, Food production, Controlled ecological life support system

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Protection effects of gasotransmitters against oxidation damager in vascular endothelial cells

*Shigeki Yoshida[1]

1. University of Tsukuba

Reactive oxygen species (ROS) are chemical species which cause cellular damage. In this presentation, I introduce protection effects of gasotransmitters against oxidation damager, and functional food components with promotion effects of gasotransmitter production.

Keywords: oxidative stress, functional food components

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Study on nutrition intake and food selection to maintain health for habitation in space

*Yasuko Kimura[1], Shunta Kimura[2,3], Hiroshi Katoh[4], Kaori Tomita-Yokotani[2]

1. Jumonji University, 2. University of Tsukuba, 3. The University of Tokyo, 4. Mie University

It is an important to proper nutrient intake in order to maintain health for habitation in space such as Mars. The intake of proper nutrients for people to maintain health depends on age, sex, physique, physical activity situation. Furthermore, there are racial differences, and each country has established nutritional requirements for health.
Here, we will consider the proper nutrient intake in the space environment based on nutritional requirements on the ground. Then we will show combinations of several species as candidates of space food material for effective nutrient intake and propose cooking recipes used their species.

Keywords: habitation in space, health, Nutritional Requirements, Nutrients, food materials

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Limit of "rational optimism", Earth as CELSS, and sustainability of human-being

*Masanori Shinohara[1]

1. Teikyo University of Science

Today, we have two conflictive forecasts for our future. One is rational optimistic prosperity (e.g. Matt Ridley) and the other is anxiety about sustainable development mainly from many meteorological observations. In this presentation, reviewing advanced life support systems from various aspects, and comparing the Earth ecosystem with them, the possible progress of our sustainable humanosphere will be discussed.

Keywords: Closed Ecology, Sustainability, Rational Optimism

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[E] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 301B 3F

[S-SS04] New methods for seismicity characterization

convener:Francesco Grigoli(ETH-Zurich, Swiss Seismological Service), Aitaro Kato(Earthquake Research Institute, the University of Tokyo), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Claudio Satriano(Institut de Physique du Globe de Paris), Chairperson:Francesco Grigoli(ETH-Zurich; Swiss Seismological Service)

In the last two decades the number of high quality seismic instruments being installed around the world has grown exponentially and probably will continue to grow in the coming decades. This data explosion has shown the limits of the current standard routine seismic analysis, often performed manually by seismologists. Exploiting the massive amount of data is a challenge that can be overcome by using new generation, fully automated and noise robust seismic processing techniques. In the last years waveform-based detection and location methods have grown in popularity and their application have dramatically improved seismic monitoring capability. More recently, Machine Learning techniques, which are a perfect playground for data-intensive applications, are showing promising results in seismicity characterization applications opening new horizons for the development of innovative, fully automated and noise robust seismic analysis methods. Such techniques are particularly useful when working with datasets characterised by a massive number of weak events with low signal-to-noise ratio, such as those collected in induced seismicity and volcanic monitoring operations. This session aims to bring to light new methods that can be applied to large datasets, either retro-actively or in near-real time, to characterize seismicity (i.e. detection, location, magnitude and source mechanisms estimation) at different scales and in different environments. We thus encourage contributions that demonstrate how the proposed methods helps improve our understanding of earthquake and/or volcanic processes.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS04-01] MyShake: A global smartphone seismic network to characterize urban earthquakes

*Richard M Allen[1], Qingkai Kong[1], Sarina Patel[1], Robert Martin-Short[1] (1.University of California Berkeley)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS04-02] Full waveform-based automatic monitoring of microseismic activity using high sampling rate records: application to Garpenberg mine (Sweden)

★Invited Papers

*Natalia Poiata[1,2], Kadek Hendrawan Palgunadi[3], Jannes Kinscher[4], Pascal Bernard[1], Francesca De Santis[4], Emmanuelle Klein[4] (1.Institut de Physique du Globe de Paris, France, 2.National Institute for Earth Physics, Romania, 3.King Abdullah University of Science and Technology, Thuwal, Saudi Arabia, 4.Institut National de l'Environnement Industriel et des Risques Ineris, Nancy, France)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS04-03] A deep convolutional neural network for localizing and detecting earthquake swarm activity based on full waveforms: Chances, challenges and questions

★Invited Papers

*Marius Kriegerowski[1,2], Gesa Maria Petersen[1,2], Hannes Vasyura Bathke[2], Matthias Ohrnberger[2] (1.German Research Centre for Geosciences Potsdam, Germany, 2.Inst. of Geosciences, University of Potsdam, Germany)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS04-04] **Fast Location Parameters Determination of Seismic Events from Few Seconds of P Wave Recorded at a Single Seismological Station Using Support Vector Machine Regression**

*Luis Hernan Ochoa Gutierrez[1], Carlos Alberto Vargas Jimenez[1], Luis Fernando Niño Vasquez[1] (1.Universidad Nacional de Colombia)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS04-05] Foreshock activity detection by a threshold-free matched-filter technique

*Shiro Hirano[1], Hironori Kawakata[1], Issei Doi[2] (1.Department of Physical Science, College of Science and Engineering, Ritsumeikan University, 2.Disaster Prevention Research Institute, Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SSS04-06] Automated seismic event detection and localization: An application to long-period seismicity at Aso Volcano influenced by large earthquake

*Andri Hendriyana[1,3], Takeshi Tsuji[1,2] (1.International Institute for Carbon-Neutral Energy Research, 2.Kyushu University, 3.Bandung Institute of Technology)

MyShake: A global smartphone seismic network to characterize urban earthquakes

*Richard M Allen[1], Qingkai Kong[1], Sarina Patel[1], Robert Martin-Short[1]

1. University of California Berkeley

MyShake is a smartphone-based seismic network now collecting seismic data around the globe. Since its launch in 2016, over 300,000 people have downloaded the free public app. Once installed on a private phone, the phone goes into monitoring mode when it is stationary. Any subsequent motion is evaluated by an artificial neural network on the phone to determine if it is earthquake-like. If it is, then a trigger is sent to the MyShake servers immediately, and 5 minutes of 3-component acceleration data is collected and uploaded to the server (including 1 minute of data before the trigger). A real-time clustering algorithm detects earthquakes on the server and the location and magnitude is estimated. So far, MyShake has collected seismic waveforms for more than 900 global earthquakes.

In 2019 version 2.0 of MyShake will be launched. It will be available for Android and iPhones and will provide additional user functionality. The system will have an earthquake early warning capability providing rapid alerts to users when earthquakes are detected. In addition to the phones recording ground motions, users will also be able to report their experience in earthquakes and any damage observed. The resulting information about the distribution of shaking and damage will be immediately available to users as they try to understand the impact of an earthquake that has just occurred.

We will report on the use of the acceleration data to characterize earthquakes. In addition to detecting and locating earthquakes in regions that do not have traditional seismic networks, MyShake can also be used to map the distribution of ground shaking including the response of buildings.

Keywords: Machine learning, Earthquake detection, Earthquake early warning

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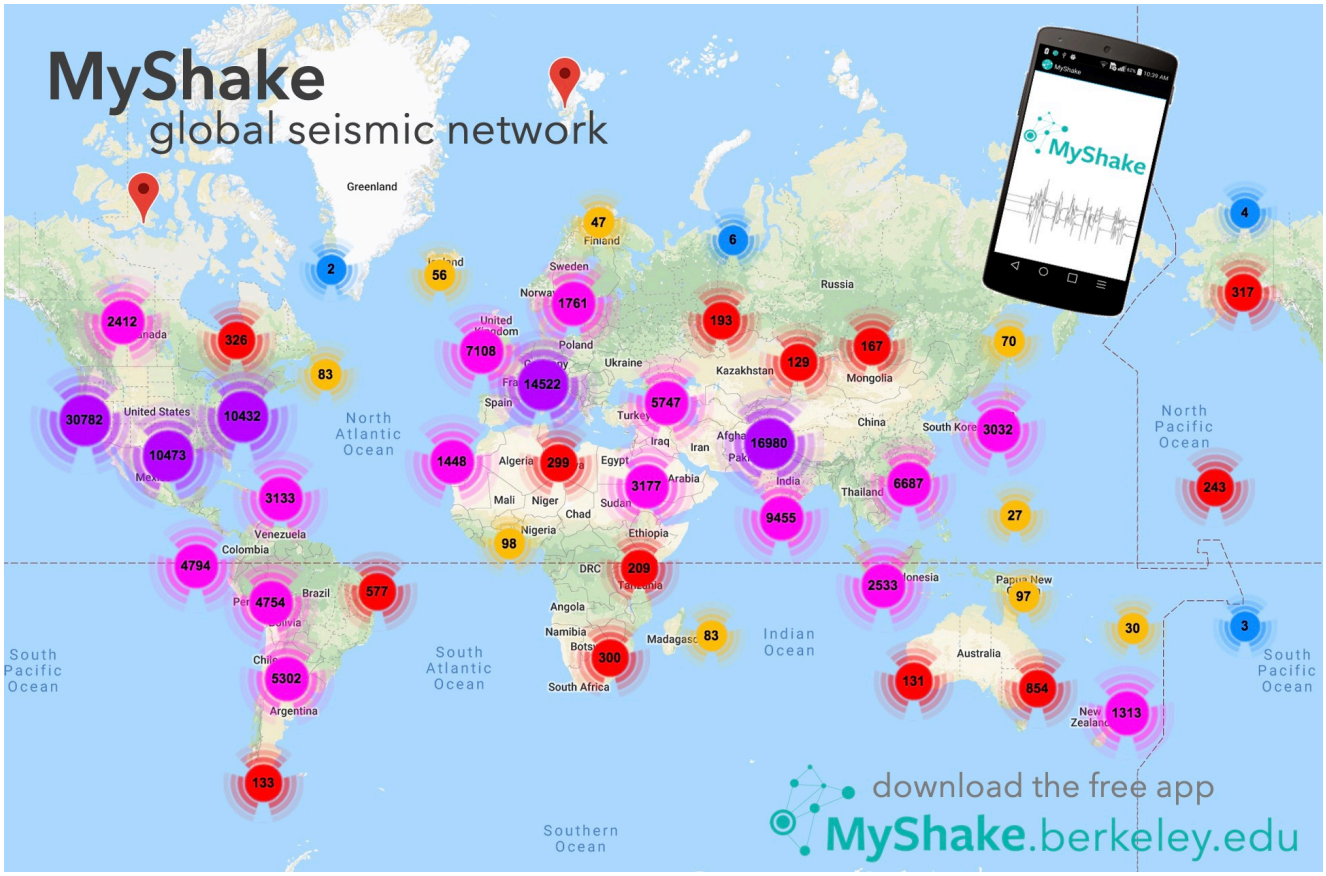

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Full waveform-based automatic monitoring of microseismic activity using high sampling rate records: application to Garpenberg mine (Sweden)

*Natalia Poiata[1,2], Kadek Hendrawan Palgunadi[3], Jannes Kinscher[4], Pascal Bernard[1], Francesca De Santis[4], Emmanuelle Klein[4]

1. Institut de Physique du Globe de Paris, France, 2. National Institute for Earth Physics, Romania, 3. King Abdullah University of Science and Technology, Thuwal, Saudi Arabia, 4. Institut National de l’ Environnement Industriel et des Risques Ineris, Nancy, France

Recent studies demonstrated success of automatic full waveform detection and location methods in analyzing and monitoring natural and induced seismicity. These approaches provided a significant improvement in events detectability increasing the significance of statistical analysis permitting to identify small changes of seismicity rates in space and time. It is expected that application of full waveform-based method to seismic monitoring of active mines could significantly improve forecasting of potential destructive rock-burst events. However, such implementations are currently non-trivial and by far nonstandard. Main challenges here come from the presence of a wide range of seismic sources related to mining activity and a high sampling rates of recorded data (~ kHz) posing problems for real-time data transfer and processing.

We present an adapted, full waveform-based automatic method for detection and location of microseismic events that makes use of continuous seismic records from an in-mine seismic network. The method can be adjusted to a real-time monitoring scheme and consists of two steps: event extraction and amplitude ratio-base preliminary location; and event relocation using coherency-based backprojection approach. The event extraction based on multi-band 2-D signal characterization allows to overcome the challenge of high sampling rate data (8 kHz), reducing the overall volume of transferred data and providing an energy-based signal classification scheme for removing signals from machinery noise sources. The technique is developed and tested on the case study of Garpenberg mine (Sweden) monitored by a high-resolution permanent local seismic network maintained by Ineris. We demonstrate the improvement in event detection capacity offered by our method in comparison to the standard triggered-based monitoring schemes and discuss how the increased number of detected microseismic events permits to better characterize the response of the mine to production activity.

Keywords: full waveform methods, mining induced seismicity, automatic monitoring, continuous data analysis

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A deep convolutional neural network for localizing and detecting earthquake swarm activity based on full waveforms: Chances, challenges and questions

*Marius Kriegerowski[1,2], Gesa Maria Petersen[1,2], Hannes Vasyura Bathke[2], Matthias Ohrnberger[2]

1. German Research Centre for Geosciences Potsdam, Germany, 2. Inst. of Geosciences, University of Potsdam, Germany

Deep learning approaches have outperformed established methods in various disciplines in recent years. Earthquake localization is a crucial first step for seismological studies. We explore in howfar deep learning regression can be used for that task when operating on three component full waveform recordings of regional stations. We implemented a deep convolutional neural network with three output neurons representing the three Cartesian coordinates of the hypocenter under investigation. We apply only basic preprocessing like filtering and use of absolute amplitudes. We trained the neural network on full waveform recordings of the 2008 North Bohemia earthquake swarm recorded by 9 stations. Accurate locations based on double difference arrival times are available and provide us with a favorable testing environment. We select time windows based on hand picked first arrivals at the closest station. We consider this approach as semi-automatic as the current implementation requires the earliest arrival at the closest station to be picked. After training for approximately 1 hour on a dataset of 2000 events we locate a different set of 900 events to validate and evaluate the location performance. The results show location accuracies of 56.4 m in East-West-,123.8 m in North-South- and 136.3 m in vertical directions compared to the double difference relocated reference catalog. It takes about 1 second to locate all 900 target events. Furthermore, we demonstrate, that the filters of the first layer can be exploited as an event detector for earthquakes of the same source region. During training, these filters become sensitive to the signals they are trained on, similar to a pattern matching detector commonly used in seismology.
A drawback of the proposed approach is the fixed station geometry. We discuss an alternative approach which allows to apply this method independent of station configurations.

Keywords: Deep learning, Machine learning, Earthquake Swarm

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Fast Location Parameters Determination of Seismic Events from Few Seconds of P Wave Recorded at a Single Seismological Station Using Support Vector Machine Regression

*Luis Hernan Ochoa Gutierrez[1], Carlos Alberto Vargas Jimenez[1], Luis Fernando Niño Vasquez[1]

1. Universidad Nacional de Colombia

A Support Vector Machine Regression (SVMR) algorithm was applied to calculate Local Magnitude (ML), epicenter distance, focal depth and back-azimuth of seismic events using only five seconds of signal since P wave onset of one three component of “El Rosal” seismic station located, near to the city of Bogota –Colombia. The algorithm was trained with descriptors of time signals of 863 seismic events acquired between January 1998 and October 2008. During training stages of SVMR several combinations of kernel function exponent and complexity factor were considered for time signals of 5, 10 and 15 seconds along with earthquake local magnitudes of 2.0, 2.5, 3.0 and 3.5. Input parameters were an exponential function of waveform envelope estimated by least squares and maximum value of recorded waveforms for each component of the seismic station as well as a “Polarity Attenuation Factor”, which is proposed as a key for a successful modelling parameter for short time earthquake characterization. We used SVMR algorithm with normalized polynomial kernel and tested with a ten-fold cross validation, obtaining mean absolute error for different exponents and complexity parameters. A grid search method was applied to choose the best model parameters. The mean absolute error obtained in estimation of parameters were: Local Magnitude (ML) with 0.19 units of magnitude, hipocentral distance with 10.3 kilometers, focal depth with 16.5 kilometers and back-azimuth with 45.4 degrees. Proposed algorithm is easy to implement directly in the seismological stations to generate fast decisions at seismic control centers, increasing the possibility of having an effective early warning generation.

Keywords: Earthquake Early Warning, Support Vector Machine Regression, Polarity Attenuation Factor, Earthquake, Bogotá, Colombia, Location Parameters

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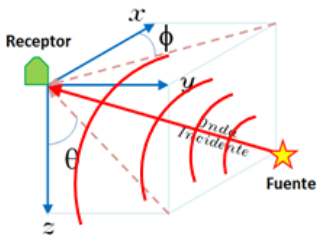

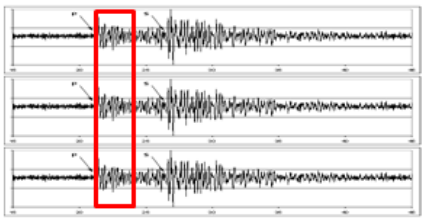

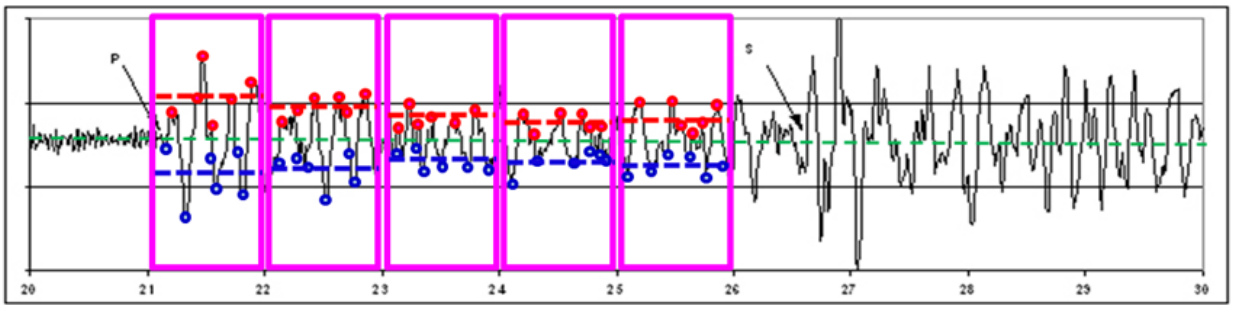

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Foreshock activity detection by a threshold-free matched-filter technique

*Shiro Hirano[1], Hironori Kawakata[1], Issei Doi[2]

1. Department of Physical Science, College of Science and Engineering, Ritsumeikan University, 2. Disaster Prevention Research Institute, Kyoto University

Revisiting earthquake catalogs have revealed that 40% or more of major earthquakes are accompanied by foreshock activities, at least in California [Abercrombie & Mori 1996 Nature] and Japan [Tamaribuchi et al. 2018 EPS].
To investigate whether the foreshocks are magnification and activation of background seismicity, we have to compare waveforms due to the foreshocks and background events that might be sometimes uncataloged because of their small sizes.
We can mine even small seismic signals similar to some template waveforms from continuous waveform records by using a matched-filter analysis based on cross-correlation coefficients (CC) between the template waveforms and continuous records.
However, in the conventional analysis, we have to define a threshold of CC to detect similar seismic waveforms, which have been chosen subjectively and empirically.
Then, we propose a threshold-free method to detect outliers from the empirical distribution of CC among seismic waveforms.
In our framework, empirical distributions of the coefficients are modeled by the theory of extreme value statistics, and the detectability is automatically determined from Akaike's Information Criterion (AIC), depending on data.
We applied the method of seismic signal detection to 2-years-continuous records before an M5.4 earthquake in Nagano, Japan (June 30, 2011) that followed 27 foreshocks cataloged by JMA.
First, we found that the empirical frequency distribution of CC between the continuous records and foreshocks did not follow a normal distribution, which means that we cannot estimate the possibility of a false positive by assuming the normal distribution as a model.
Instead, we also found that the maximum value of CC in every few seconds follow the Gumbel distribution after elimination of some outliers.
The elimination can be achieved by comparing AICs of data including and excluding the outlier candidates.
Given this method, we found a similar event ~2 months before the mainshock and 3 similar events 3-4 days before the mainshock.
This result implies that the foreshocks were not similar to background events, and hence, not magnification or activation of them.

Keywords: matched-filter technique, foreshock activity, extreme value statistics, AIC

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Automated seismic event detection and localization: An application to long-period seismicity at Aso Volcano influenced by large earthquake

*Andri Hendriyana[1,3], Takeshi Tsuji[1,2]

1. International Institute for Carbon-Neutral Energy Research, 2. Kyushu University, 3. Bandung Institute of Technology

The interplay between earthquakes and volcanic activity that may lead to eruptions has been well-established. Dynamic stress from a remote large earthquake brought by propagating of body and surface waves triggers gas exsolution at a magma reservoir. The exsolution of gasses could further lead to a bubble nucleation and pressurize the magma chamber. If the pressure continues to increase and exceeds a critical value, then magmatic fluids could breach impermeable layers overlying the magma chamber. Hot magmatic fluids heat up water filling hydrothermal system or continue to rise until surface resulting in an eruption. The interaction between the ascent of magmatic fluids with water at shallow triggers long-period (LP) seismicity. LP events reflect the resonance of fluid-filled cracks due to changes in fracture pressure. Because this process usually occurs near the surface, then LP seismicity could be used as a possible precursor to volcanic eruptions. Many studies have been conducted to analyse LP seismicity at Aso volcano. The origin of this seismic activity was a pressurization at the hydrothermal system at depth of about 1 km from the surface. However, the relationships between LP seismicity and earthquakes have not been studied. Moreover, LP signals show no clear onset of wave arrivals causing difficulties in performing classical seismic event localization that relies on manual travel-time picking. In this study, we present the source location of LP (with period of 15 s) seismicity at Aso volcano recorded by F-net and V-net seismic networks, between January 2015 and December 2016, a period that includes the Mw 7.0 Kumamoto earthquake of April 2016 and volcanic eruptions of October 2016. The initial LP events were identified by applying STA/LTA method using window lengths of 10 s and 100 s. To avoid false positive detection, waveform cross-correlation was applied to all pairs of the initial events resulting in a reliable three-component template waveform. In order to obtain robust LP events from 2-year continuous seismograms, a template matched filter was employed. We developed a differential-time back-projection method to locate LP events. Then, a coherency measure (semblance) was computed from the cross-correlograms of waveforms instead of the seismograms. In order to increase the focusing of the coherency image, we applied weighted-semblance by making use of a phase-stacking function. The seismic event locations with uncertainties were estimated from the probability density function of the coherency image. The performance of the developed method was remarkable since we have successfully revealed two distinct clusters of LP seismicity beneath the Nakadake crater. The spatio-temporal variation of LP events could be related to the large earthquake and volcanic eruption.

Keywords: differential-time, back projection technique, template matched filter, coherency, long-period seismicity

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[E] Poster | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_13

[S-SS04] New methods for seismicity characterization

convener:Francesco Grigoli(ETH-Zurich, Swiss Seismological Service), Aitaro Kato(Earthquake Research Institute, the University of Tokyo), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Claudio Satriano(Institut de Physique du Globe de Paris)

In the last two decades the number of high quality seismic instruments being installed around the world has grown exponentially and probably will continue to grow in the coming decades. This data explosion has shown the limits of the current standard routine seismic analysis, often performed manually by seismologists. Exploiting the massive amount of data is a challenge that can be overcome by using new generation, fully automated and noise robust seismic processing techniques. In the last years waveform-based detection and location methods have grown in popularity and their application have dramatically improved seismic monitoring capability. More recently, Machine Learning techniques, which are a perfect playground for data-intensive applications, are showing promising results in seismicity characterization applications opening new horizons for the development of innovative, fully automated and noise robust seismic analysis methods. Such techniques are particularly useful when working with datasets characterised by a massive number of weak events with low signal-to-noise ratio, such as those collected in induced seismicity and volcanic monitoring operations. This session aims to bring to light new methods that can be applied to large datasets, either retro-actively or in near-real time, to characterize seismicity (i.e. detection, location, magnitude and source mechanisms estimation) at different scales and in different environments. We thus encourage contributions that demonstrate how the proposed methods helps improve our understanding of earthquake and/or volcanic processes.

[SSS04-P01] Constraint of focal mechanisms of induced seismicity by using misfit angles based on known *in-situ* stress

*Yusuke Mukuhira[1], Makoto Naoi[2], Michael C Fehler[3], Hirokazu Moriya[5], Takatoshi Ito[1], Hiroshi Asanuma[4], Markus O Häring[6] (1.Institute of Fluid Science, Tohoku University, 2.Disaster Prevention Research Institute, Kyoto University, 3.Earth Resources Laboratory, MIT, 4.FREA, AIST, 5.School of Engineering, Tohoku University, 6.Häring GeoProject)

[SSS04-P02] Kinematic slip imaging of the Mw 3.3 earthquake in the St. Gallen 2013 geothermal reservoir, Switzerland, using an isochrone back projection approach

*Claudio Satriano[1], Eszter Király-Proag[2], Pascal Bernard[1], Stefan Wiemer[2] (1.Institut de Physique du Globe de Paris, France, 2.ETH Swiss Federal Institute of Technology Zurich, Switzerland)

[SSS04-P03] Monitoring induced seismicity with a single seismic station by combining coda wave interferometry with distance geometry solvers

*Francesco Grigoli[1], Simone Cesca[2], Alessandro Vuan[3], Filippo Broggini[1], John Clinton[1], Stefan Wiemer[1] (1.ETH-Zurich, Switzerland, 2.GFZ-Potsdam, Germany, 3.OGS-Trieste, Italy)

[SSS04-P04] Automatic Earthquake Locating by Stacking Characteristic Functions in a Source Scanning Method

★Invited Papers

*Hilary Chang[1], Alison Malcolm[1], Frédérick Massin[2], Francesco Grigoli[2] (1.Memorial University of Newfoundland, Earth Sciences, Canada, 2. ETH Zurich, Department of Earth Sciences, Zürich, Switzerland)

[SSS04-P05] Earthquake nowcasting: further development and application to Japan

*Kazuyoshi Nanjo[1], John B. Rundle[2], Tetsuo Sakurada[3] (1.University of Shizuoka, 2.University of California at Davis, 3.SAKURADA&Company)

Constraint of focal mechanisms of induced seismicity by using misfit angles based on known *in-situ* stress

*Yusuke Mukuhira[1], Makoto Naoi[2], Michael C Fehler[3], Hirokazu Moriya[5], Takatoshi Ito[1], Hiroshi Asanuma[4], Markus O Häring[6]

1. Institute of Fluid Science, Tohoku University, 2. Disaster Prevention Research Institute, Kyoto University, 3. Earth Resources Laboratory, MIT, 4. FREA, AIST, 5. School of Engineering, Tohoku University, 6. Häring GeoProject

Microseismic monitoring is essential for successful hydraulic stimulation/fracking in unconventional oil/gas development, engineered geothermal system development and carbon capture and sequestration. In addition to the hypocenter location of the microseismicity, knowledge of the geometry of the fracture is also crucial for better understanding of fractured reservoir, fluid flow, and design of the energy extraction. Geofluid flows in the fracture and its permeability are correlated with the relation of the geometry of the fracture and in-situ stress. Fracture orientation can be estimated by the seismological method such as moment tensor inversion or focal mechanism analysis, only when the waveforms of the events are well recorded by a number of well-distributed stations. However, in realistic microseismic monitoring situations, it is often difficult to constrain the focal mechanism of microseismicity from first motion information due to the small number of stations.

We proposed a method to improve the estimates of focal mechanisms by introducing in-situ stress information from borehole logging information. We eliminate candidate focal mechanisms that are consistent with first motion data but cannot have shear slip under a given stress state and pore pressure increase. In this study, we also check the consistency between the shear slip vector estimated from the stress state and the rakes. We compare the shear slip vector and the slip vector from the rake. Then we reject the fault if the difference in the two vectors is significantly large. With this process, we reject the fault planes and auxiliary planes which are not consistent with stress state. We apply this method to induced seismicity dataset from Basel, Switzerland, where we already have well-constrained focal mechanisms estimated by many surface stations over a large region. We use these focal mechanisms as references to check whether our method can constrain the range of focal mechanisms using a small number of nearby stations. We find that the consistency check between two vectors significantly and reliably limits the range of focal mechanisms. Furthermore, we combine the constrained range of focal mechanism by this method and that by stability analysis to have more constraint of focal mechanisms satisfying the conditions of the geomechanical problem.

Keywords: Induced seismicity, Focal mechanism, In-situ stress

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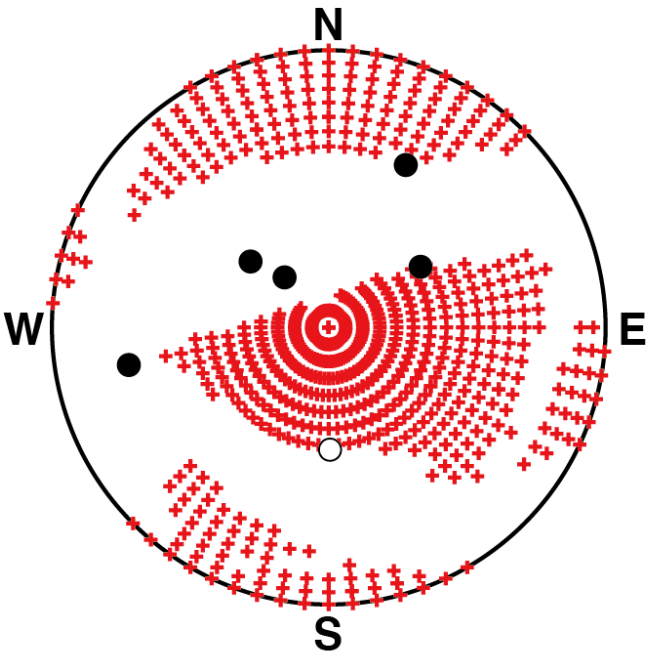

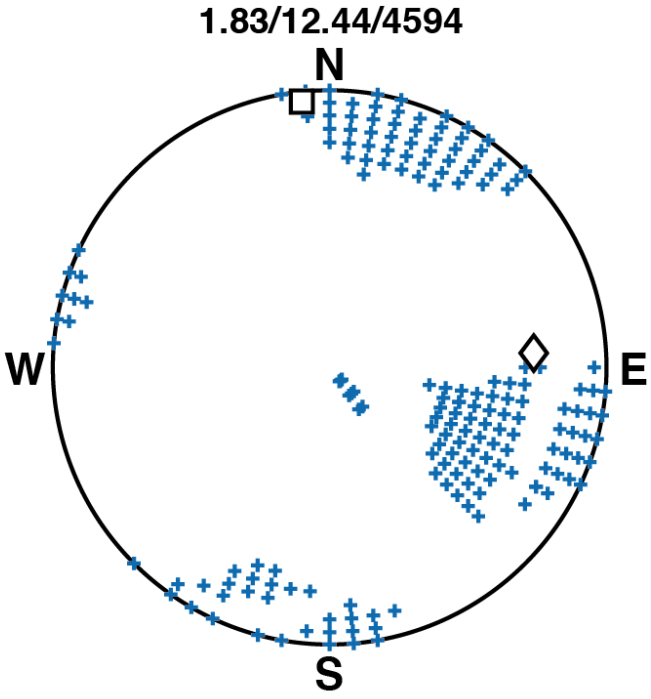

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Kinematic slip imaging of the Mw 3.3 earthquake in the St. Gallen 2013 geothermal reservoir, Switzerland, using an isochrone back projection approach

*Claudio Satriano[1], Eszter Király-Proag[2], Pascal Bernard[1], Stefan Wiemer[2]

1. Institut de Physique du Globe de Paris, France, 2. ETH Swiss Federal Institute of Technology Zurich, Switzerland

In most models and analyses, small earthquakes (i.e., M<4) are considered either point sources or "penny-shaped" solid surfaces with homogeneous or isotropic source properties. While these assumptions may be valid, details of individual earthquakes are more complex. Due to the insufficient resolution of most monitoring networks, micro-earthquakes (M<2) must be still approximated as dislocation on penny-shaped surfaces. But in case of larger events (M>3) recorded on well-distributed local seismic stations, detailed space-time slip pattern within the rupture area can be imaged.

Here, we analyze slip distribution and rupture kinematics of a moderate induced event (ML 3.5) occurred in the St. Gallen geothermal reservoir (NE Switzerland) in 2013. To image the slip of such a small magnitude earthquake, we carry out a two-step procedure: (1) we deconvolve the propagation effects from the seismograms using an empirical Green's function resulting in relative source time functions (RSTF) at all seismic stations; (2) the RSTFs are back-projected to the fault plane using the position of equal time delays, i.e., isochrones.

Results reveal that the mainshock rupture propagates towards NNE from the hypocenter with an average velocity of about 2000 m/s. Spatio-temporal organization of fore- and aftershocks suggests that the mainshock released a previously less active portion of the fault and that the sequence is mainly stress-driven.

Applying this method in an operational environment could enable to quickly map seismic slip allowing assessment of fault asperities and structures involved in the reservoir creation process.

Keywords: Earthquake Source, Earthquake Kinematics, Back Projection, Induced Seismicity

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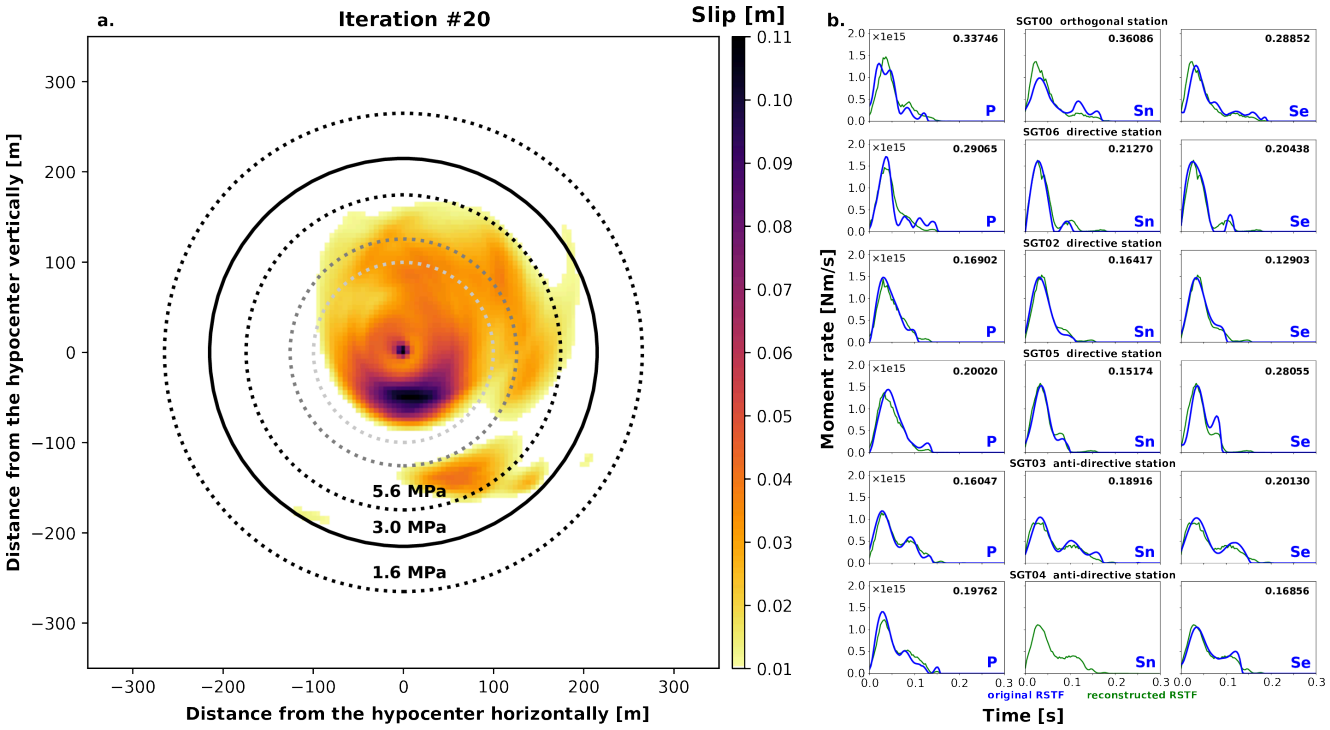

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Monitoring induced seismicity with a single seismic station by combining coda wave interferometry with distance geometry solvers

*Francesco Grigoli[1], Simone Cesca[2], Alessandro Vuan[3], Filippo Broggini[1], John Clinton[1], Stefan Wiemer[1]

1. ETH-Zurich, Switzerland, 2. GFZ-Potsdam, Germany, 3. OGS-Trieste, Italy

Microseismic monitoring networks are nowadays extensively used, in combination with risk analysis tools, to ensure the safety of the industrial operations which may trigger or induce earthquakes. However, in many cases the lack of dense enough microseismic monitoring networks affects the performance of the routine data analysis procedures limiting the application of adequate risk mitigation strategies. In this work we propose a novel approach based on the combination of Coda Wave Interferometry (CWI) and Distance Geometry Solvers (DGS) that allow to locate microseismic events by using a single seismic station. The use of CWI allows to determine, for pairs of earthquakes characterized by high similarity of waveforms (i.e. with similar location and focal mechanism), the absolute inter-event distance of each pair (Snieder and Vrijlandt, 2005), while DGS allow to determine their location based only on the given values of the distances between member pairs. Microseismic events can be classified in different families by combining a waveform correlation analysis and a clustering technique. Clustered events are characterized by a high similarity of waveforms, which implies a similarity in both source mechanism and location. In these conditions, the analysis of seismic coda recorded at a single receiver can be used to infer a measure of the spatial separation between two seismic sources. Coda waves are radiated in all directions with a radiation pattern determined by the source mechanism and a small change in the source position affects the interference pattern of the scattered waves that constitute the coda. This change in the coda waves is used to constrain the inter-event distance for each events pair. Absolute locations can be then retrieved by using DGS and considering all inter-event distances, a procedure which requires at least four reference locations. In order to show the potential of this approach we firstly validated the method with a synthetic dataset, then we applied it to the September-October 2013 induced seismicity sequence associated to the underground gas storage operations performed in the offshore Spain. The largest event of the sequence, a magnitude Mw 4.3 earthquake occurred on 2013 October 4th, was preceded by about 1000 seismic events, mostly with magnitude below 2. However, the poor monitoring network in the area (the closest seismic station was located at about ~20 km distance from the platform) did not allow to properly locate these small events. In this work we relocate these low magnitude events, showing that our approach provides better results than those obtained by using standard location methods, making this method particularly useful in poorly monitored areas where only a limited number of stations is available.

References:

Snieder, R., and Vrijlandt, M., 2005. Constraining the source separation with coda wave interferometry: Theory and application to earthquake doublets in the Hayward fault, California, J. Geophys. Res., doi:10.1029/2004JB003317

Keywords: Coda Wave Interferometry, Microseismicity, Induced Seismicity

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Automatic Earthquake Locating by Stacking Characteristic Functions in a Source Scanning Method

*Hilary Chang[1], Alison Malcolm[1], Frédérick Massin[2], Francesco Grigoli[2]

1. Memorial University of Newfoundland, Earth Sciences, Canada, 2. ETH Zurich, Department of Earth Sciences, Zürich, Switzerland

Exact source locating for microseismic events helps us understand subsurface structures, monitor volcanic activities and assess earthquake hazards. Conventionally, the locating problem can be solved by picking phase arrivals. However, for microseismicity which contains large numbers of low-magnitude events, phase picking is often difficult and time-consuming. In this research, we use an improved waveform-based method to locate microseismic events without phase picking. We use the Source Scanning Algorithm (SSA) to stack the Characteristic Functions (CFs) in time and space, where the maximum stack gives the best estimate of the event origin time and source location. This approach allows us to locate the event automatically by evaluating waveform coherency in terms of changes in amplitude and polarization. We conduct synthetic test using the geometry of the SIL network in Reykjane Peninsula, SW Iceland. The results show that we can locate the synthetic source with error <1km, <0.1s when the noise amplitude is less than the amplitude of the target phase. In addition, stacking CFs that evaluate changes in amplitudes gives more stable results at all noise level, while stacking CFs that consider changes in polarization gives more stable results when the noise varies with frequency. We also conduct field data test using 215 microseismic events (M<2) occurred during Aug 2010 and Mar 2011 recorded by the same network. Our results show that stacking CFs that considers changes in amplitudes gives the closest results to the manually picking method, while stacking a combined version of CF rejects more outliers. In summary, stacking CFs in the SSA provides us with the ability to consider different waveform characteristics and improved noise-robustness in source locating problems. This improved automatic waveform-based procedure offers reliable solutions to large data set with low SNR and helps reduce human intervention.

Keywords: earthquake location, source scanning algorithm, waveform characteristics

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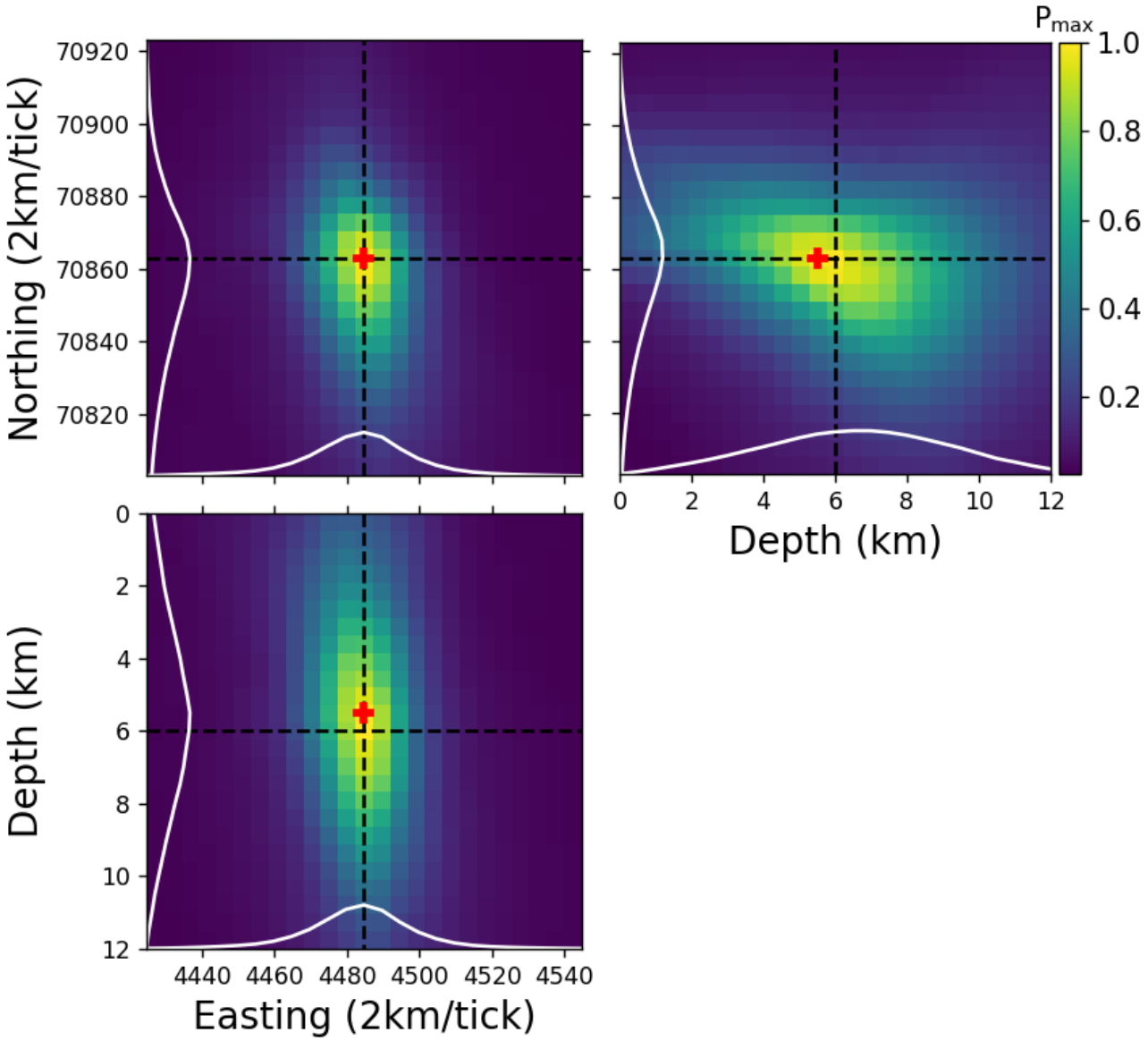

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Earthquake nowcasting: further development and application to Japan

*Kazuyoshi Nanjo[1], John B. Rundle[2], Tetsuo Sakurada[3]

1. University of Shizuoka, 2. University of California at Davis, 3. SAKURADA&Company

We adopted and further developed the earthquake nowcasting method (Rundle et al., 2016). This method determines the current state of the fault system in a predefined region and its current level of progress through the earthquake cycle, using only empirical data: magnitudes (M) and times of earthquakes in the region. The characteristic is that the method does not involve any model other than the idea of an earthquake cycle. We performed a case study from southern Kanto, using the earthquake catalog maintained by Japan Meteorological Agency (JMA). Two earthquake magnitudes are selected, one large ($M \geqq M_L$), and one small ($M \geqq M_S$), where $M_L > M_S$. The method utilizes the number of small earthquakes that occurs between pairs of large earthquakes. The cumulative probability distribution of these values is obtained. The earthquake potential score (EPS), an index of the current level of the progress through the earthquake cycle, is defined by the “natural time”, the number of small earthquakes that has occurred since the last large earthquake, the point where this number falls on the cumulative probability distribution. For southern Kanto, we used earthquakes since 1926 with depths shallower than 150 km and set M_L=6.0 and M_S=4.2. The obtained result as of December 20, 2018 is EPS of 8%. This is interpreted as an indication that if a large (M6+) earthquake occurred on this date, the recurrence interval would be relatively short. Errors that arise from statistics-based estimation such as this must be considered so that we introduced the calculation of uncertainties to the earthquake nowcasting, using a bootstrap approach. Taking into account the contribution of these errors to the EPS calculations, we conclude that the earthquake nowcasting generates stable estimates of EPS for southern Kanto (Nanjo, 2018). To check the stability estimation for other regions, we computed EPS and its uncertainty for selected regions in Japan. We also discuss a technique of spatial mapping of EPS over the Japan’s mainlands. This technique allows us to move towards a full description of current EPS as a function of space, providing possible usability for ranking locations on the earthquake hazard.

Keywords: nowcasting, earthquake, natural time

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[E] Poster | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_24

[S-SS04] New methods for seismicity characterization

convener:Francesco Grigoli(ETH-Zurich, Swiss Seismological Service), Aitaro Kato(Earthquake Research Institute, the University of Tokyo), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Claudio Satriano(Institut de Physique du Globe de Paris)

In the last two decades the number of high quality seismic instruments being installed around the world has grown exponentially and probably will continue to grow in the coming decades. This data explosion has shown the limits of the current standard routine seismic analysis, often performed manually by seismologists. Exploiting the massive amount of data is a challenge that can be overcome by using new generation, fully automated and noise robust seismic processing techniques. In the last years waveform-based detection and location methods have grown in popularity and their application have dramatically improved seismic monitoring capability. More recently, Machine Learning techniques, which are a perfect playground for data-intensive applications, are showing promising results in seismicity characterization applications opening new horizons for the development of innovative, fully automated and noise robust seismic analysis methods. Such techniques are particularly useful when working with datasets characterised by a massive number of weak events with low signal-to-noise ratio, such as those collected in induced seismicity and volcanic monitoring operations. This session aims to bring to light new methods that can be applied to large datasets, either retro-actively or in near-real time, to characterize seismicity (i.e. detection, location, magnitude and source mechanisms estimation) at different scales and in different environments. We thus encourage contributions that demonstrate how the proposed methods helps improve our understanding of earthquake and/or volcanic processes.

[SSS04-P01] Constraint of focal mechanisms of induced seismicity by using misfit angles based on known *in-situ* stress

*Yusuke Mukuhira[1], Makoto Naoi[2], Michael C Fehler[3], Hirokazu Moriya[5], Takatoshi Ito[1], Hiroshi Asanuma[4], Markus O Häring[6] (1.Institute of Fluid Science, Tohoku University, 2.Disaster Prevention Research Institute, Kyoto University, 3.Earth Resources Laboratory, MIT, 4.FREA, AIST, 5.School of Engineering, Tohoku University, 6.Häring GeoProject)

[SSS04-P02] Kinematic slip imaging of the Mw 3.3 earthquake in the St. Gallen 2013 geothermal reservoir, Switzerland, using an isochrone back projection approach

*Claudio Satriano[1], Eszter Király-Proag[2], Pascal Bernard[1], Stefan Wiemer[2] (1.Institut de Physique du Globe de Paris, France, 2.ETH Swiss Federal Institute of Technology Zurich, Switzerland)

[SSS04-P03] Monitoring induced seismicity with a single seismic station by combining coda wave interferometry with distance geometry solvers

*Francesco Grigoli[1], Simone Cesca[2], Alessandro Vuan[3], Filippo Broggini[1], John Clinton[1], Stefan Wiemer[1] (1.ETH-Zurich, Switzerland, 2.GFZ-Potsdam, Germany, 3.OGS-Trieste, Italy)

[SSS04-P04] Automatic Earthquake Locating by Stacking Characteristic Functions in a Source Scanning Method

★Invited Papers

*Hilary Chang[1], Alison Malcolm[1], Frédérick Massin[2], Francesco Grigoli[2] (1.Memorial University of Newfoundland, Earth Sciences, Canada, 2. ETH Zurich, Department of Earth Sciences, Zürich, Switzerland)

[SSS04-P05] Earthquake nowcasting: further development and application to Japan

*Kazuyoshi Nanjo[1], John B. Rundle[2], Tetsuo Sakurada[3] (1.University of Shizuoka, 2.University of California at Davis, 3.SAKURADA&Company)

Constraint of focal mechanisms of induced seismicity by using misfit angles based on known *in-situ* stress

*Yusuke Mukuhira[1], Makoto Naoi[2], Michael C Fehler[3], Hirokazu Moriya[5], Takatoshi Ito[1], Hiroshi Asanuma[4], Markus O Häring[6]

1. Institute of Fluid Science, Tohoku University, 2. Disaster Prevention Research Institute, Kyoto University, 3. Earth Resources Laboratory, MIT, 4. FREA, AIST, 5. School of Engineering, Tohoku University, 6. Häring GeoProject

Microseismic monitoring is essential for successful hydraulic stimulation/fracking in unconventional oil/gas development, engineered geothermal system development and carbon capture and sequestration. In addition to the hypocenter location of the microseismicity, knowledge of the geometry of the fracture is also crucial for better understanding of fractured reservoir, fluid flow, and design of the energy extraction. Geofluid flows in the fracture and its permeability are correlated with the relation of the geometry of the fracture and in-situ stress. Fracture orientation can be estimated by the seismological method such as moment tensor inversion or focal mechanism analysis, only when the waveforms of the events are well recorded by a number of well-distributed stations. However, in realistic microseismic monitoring situations, it is often difficult to constrain the focal mechanism of microseismicity from first motion information due to the small number of stations.

We proposed a method to improve the estimates of focal mechanisms by introducing in-situ stress information from borehole logging information. We eliminate candidate focal mechanisms that are consistent with first motion data but cannot have shear slip under a given stress state and pore pressure increase. In this study, we also check the consistency between the shear slip vector estimated from the stress state and the rakes. We compare the shear slip vector and the slip vector from the rake. Then we reject the fault if the difference in the two vectors is significantly large. With this process, we reject the fault planes and auxiliary planes which are not consistent with stress state. We apply this method to induced seismicity dataset from Basel, Switzerland, where we already have well-constrained focal mechanisms estimated by many surface stations over a large region. We use these focal mechanisms as references to check whether our method can constrain the range of focal mechanisms using a small number of nearby stations. We find that the consistency check between two vectors significantly and reliably limits the range of focal mechanisms. Furthermore, we combine the constrained range of focal mechanism by this method and that by stability analysis to have more constraint of focal mechanisms satisfying the conditions of the geomechanical problem.

Keywords: Induced seismicity, Focal mechanism, In-situ stress

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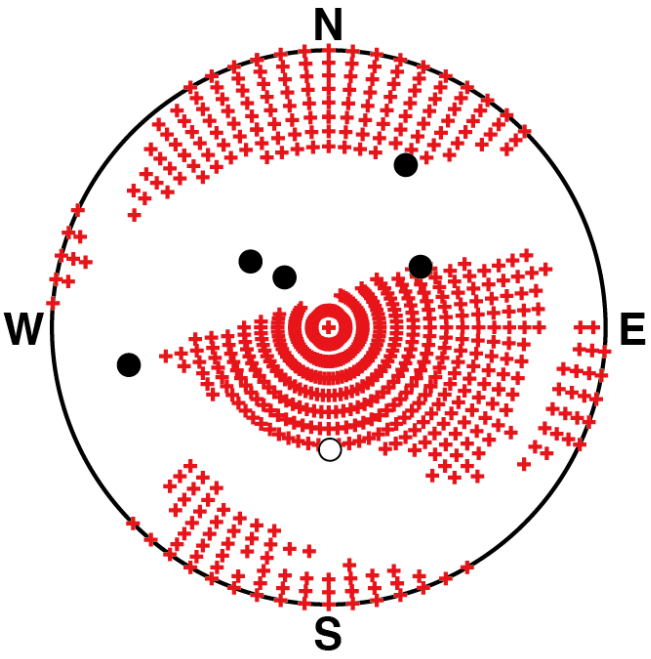

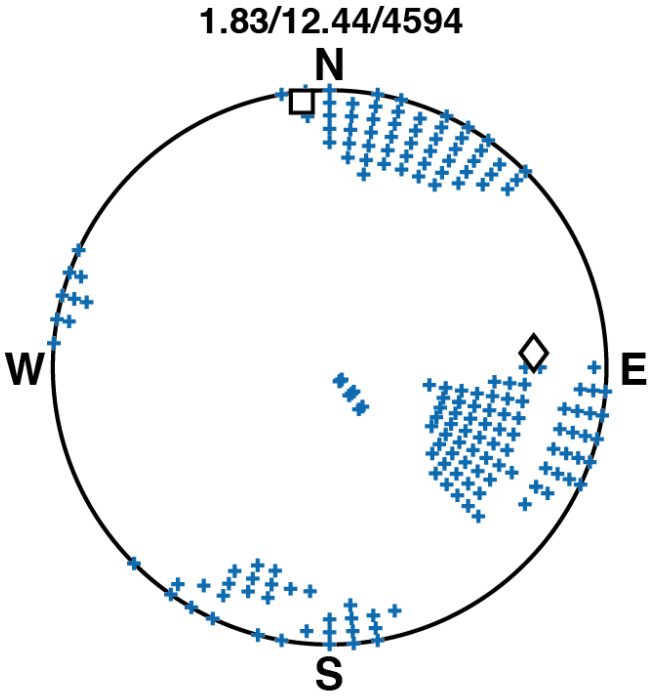

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Kinematic slip imaging of the Mw 3.3 earthquake in the St. Gallen 2013 geothermal reservoir, Switzerland, using an isochrone back projection approach

*Claudio Satriano[1], Eszter Király-Proag[2], Pascal Bernard[1], Stefan Wiemer[2]

1. Institut de Physique du Globe de Paris, France, 2. ETH Swiss Federal Institute of Technology Zurich, Switzerland

In most models and analyses, small earthquakes (i.e., M<4) are considered either point sources or "penny-shaped" solid surfaces with homogeneous or isotropic source properties. While these assumptions may be valid, details of individual earthquakes are more complex. Due to the insufficient resolution of most monitoring networks, micro-earthquakes (M<2) must be still approximated as dislocation on penny-shaped surfaces. But in case of larger events (M>3) recorded on well-distributed local seismic stations, detailed space-time slip pattern within the rupture area can be imaged.

Here, we analyze slip distribution and rupture kinematics of a moderate induced event (ML 3.5) occurred in the St. Gallen geothermal reservoir (NE Switzerland) in 2013. To image the slip of such a small magnitude earthquake, we carry out a two-step procedure: (1) we deconvolve the propagation effects from the seismograms using an empirical Green's function resulting in relative source time functions (RSTF) at all seismic stations; (2) the RSTFs are back-projected to the fault plane using the position of equal time delays, i.e., isochrones.

Results reveal that the mainshock rupture propagates towards NNE from the hypocenter with an average velocity of about 2000 m/s. Spatio-temporal organization of fore- and aftershocks suggests that the mainshock released a previously less active portion of the fault and that the sequence is mainly stress-driven.

Applying this method in an operational environment could enable to quickly map seismic slip allowing assessment of fault asperities and structures involved in the reservoir creation process.

Keywords: Earthquake Source, Earthquake Kinematics, Back Projection, Induced Seismicity

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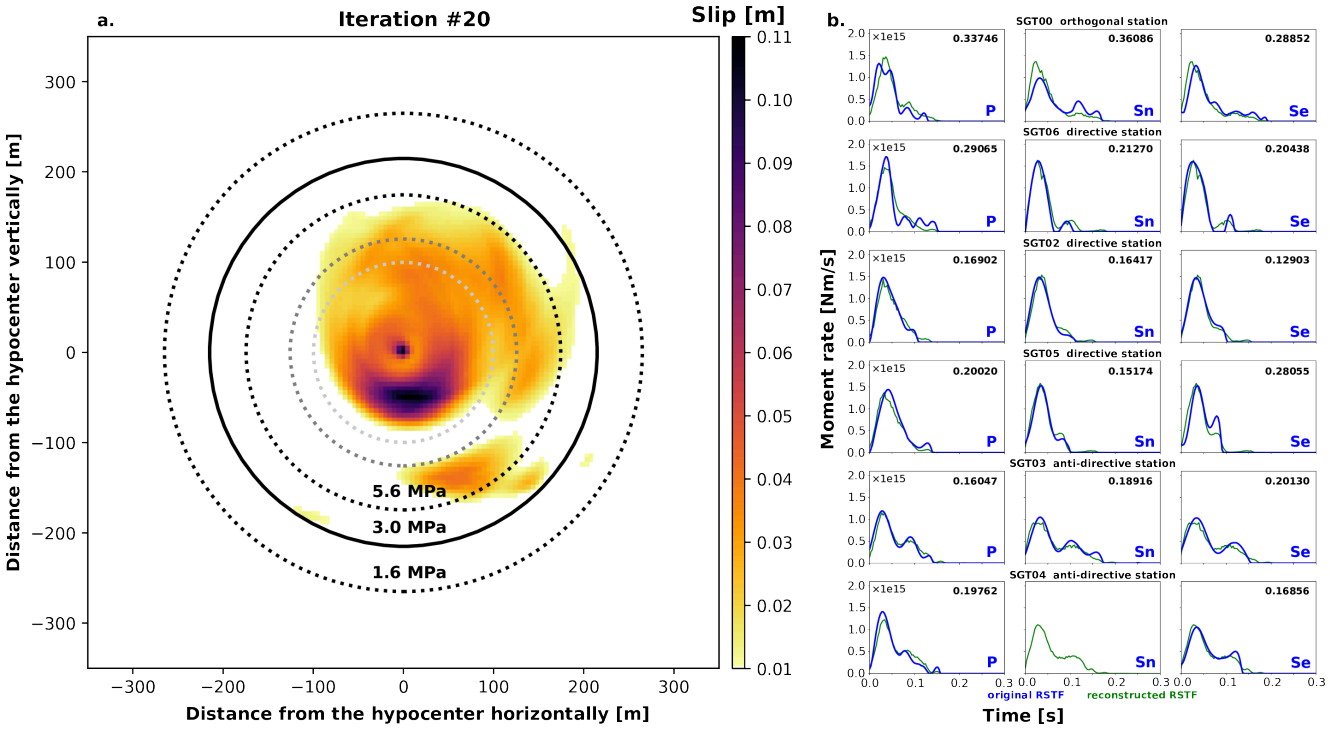

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Monitoring induced seismicity with a single seismic station by combining coda wave interferometry with distance geometry solvers

*Francesco Grigoli[1], Simone Cesca[2], Alessandro Vuan[3], Filippo Broggini[1], John Clinton[1], Stefan Wiemer[1]

1. ETH-Zurich, Switzerland, 2. GFZ-Potsdam, Germany, 3. OGS-Trieste, Italy

Microseismic monitoring networks are nowadays extensively used, in combination with risk analysis tools, to ensure the safety of the industrial operations which may trigger or induce earthquakes. However, in many cases the lack of dense enough microseismic monitoring networks affects the performance of the routine data analysis procedures limiting the application of adequate risk mitigation strategies. In this work we propose a novel approach based on the combination of Coda Wave Interferometry (CWI) and Distance Geometry Solvers (DGS) that allow to locate microseismic events by using a single seismic station. The use of CWI allows to determine, for pairs of earthquakes characterized by high similarity of waveforms (i.e. with similar location and focal mechanism), the absolute inter-event distance of each pair (Snieder and Vrijlandt, 2005), while DGS allow to determine their location based only on the given values of the distances between member pairs. Microseismic events can be classified in different families by combining a waveform correlation analysis and a clustering technique. Clustered events are characterized by a high similarity of waveforms, which implies a similarity in both source mechanism and location. In these conditions, the analysis of seismic coda recorded at a single receiver can be used to infer a measure of the spatial separation between two seismic sources. Coda waves are radiated in all directions with a radiation pattern determined by the source mechanism and a small change in the source position affects the interference pattern of the scattered waves that constitute the coda. This change in the coda waves is used to constrain the inter-event distance for each events pair. Absolute locations can be then retrieved by using DGS and considering all inter-event distances, a procedure which requires at least four reference locations. In order to show the potential of this approach we firstly validated the method with a synthetic dataset, then we applied it to the September-October 2013 induced seismicity sequence associated to the underground gas storage operations performed in the offshore Spain. The largest event of the sequence, a magnitude Mw 4.3 earthquake occurred on 2013 October 4th, was preceded by about 1000 seismic events, mostly with magnitude below 2. However, the poor monitoring network in the area (the closest seismic station was located at about ~20 km distance from the platform) did not allow to properly locate these small events. In this work we relocate these low magnitude events, showing that our approach provides better results than those obtained by using standard location methods, making this method particularly useful in poorly monitored areas where only a limited number of stations is available.

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Keywords: Coda Wave Interferometry, Microseismicity, Induced Seismicity

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Automatic Earthquake Locating by Stacking Characteristic Functions in a Source Scanning Method

*Hilary Chang[1], Alison Malcolm[1], Frédérick Massin[2], Francesco Grigoli[2]

1. Memorial University of Newfoundland, Earth Sciences, Canada, 2. ETH Zurich, Department of Earth Sciences, Zürich, Switzerland

Exact source locating for microseismic events helps us understand subsurface structures, monitor volcanic activities and assess earthquake hazards. Conventionally, the locating problem can be solved by picking phase arrivals. However, for microseismicity which contains large numbers of low-magnitude events, phase picking is often difficult and time-consuming. In this research, we use an improved waveform-based method to locate microseismic events without phase picking. We use the Source Scanning Algorithm (SSA) to stack the Characteristic Functions (CFs) in time and space, where the maximum stack gives the best estimate of the event origin time and source location. This approach allows us to locate the event automatically by evaluating waveform coherency in terms of changes in amplitude and polarization. We conduct synthetic test using the geometry of the SIL network in Reykjane Peninsula, SW Iceland. The results show that we can locate the synthetic source with error <1km, <0.1s when the noise amplitude is less than the amplitude of the target phase. In addition, stacking CFs that evaluate changes in amplitudes gives more stable results at all noise level, while stacking CFs that consider changes in polarization gives more stable results when the noise varies with frequency. We also conduct field data test using 215 microseismic events (M<2) occurred during Aug 2010 and Mar 2011 recorded by the same network. Our results show that stacking CFs that considers changes in amplitudes gives the closest results to the manually picking method, while stacking a combined version of CF rejects more outliers. In summary, stacking CFs in the SSA provides us with the ability to consider different waveform characteristics and improved noise-robustness in source locating problems. This improved automatic waveform-based procedure offers reliable solutions to large data set with low SNR and helps reduce human intervention.

Keywords: earthquake location, source scanning algorithm, waveform characteristics

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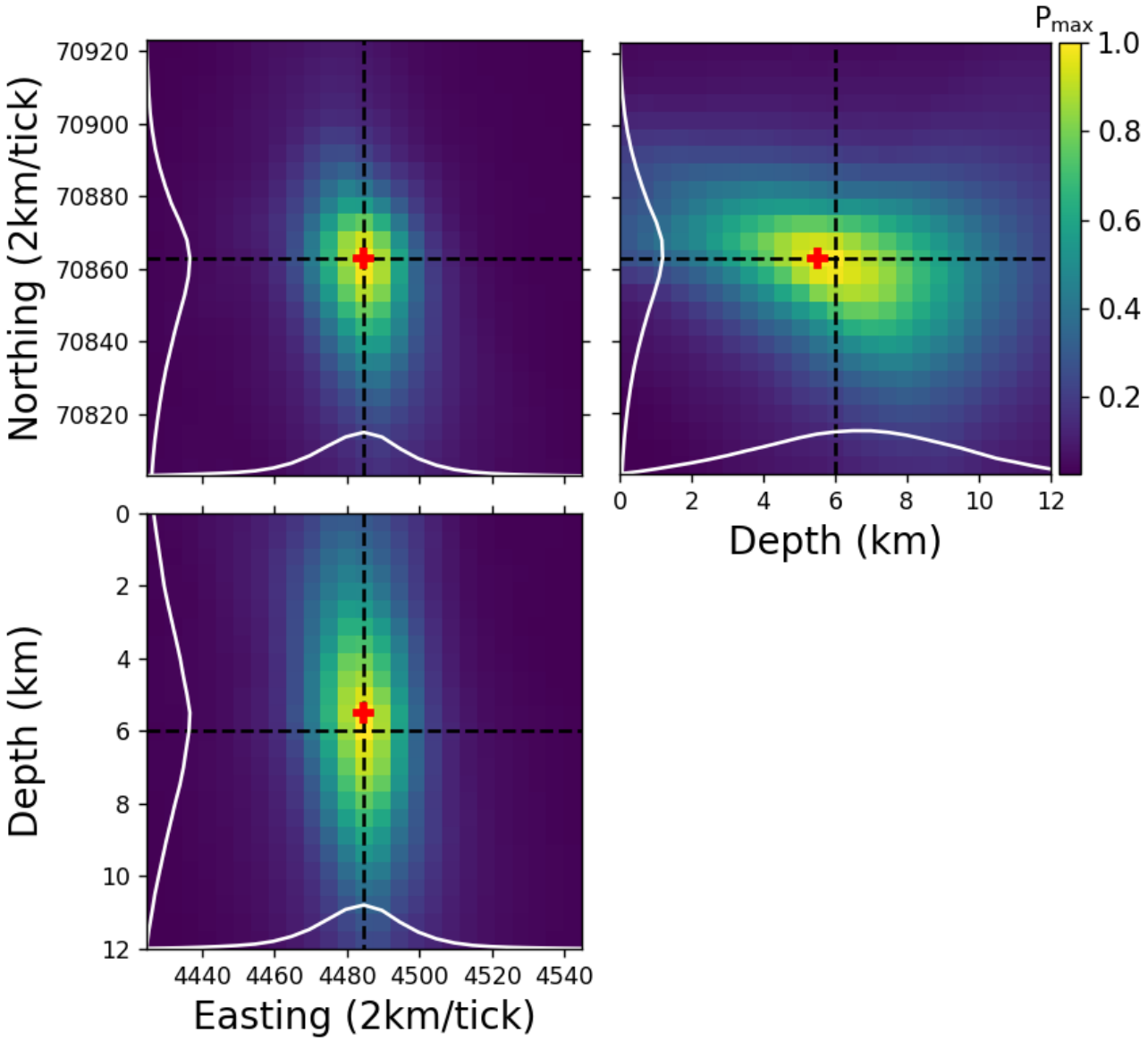

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Earthquake nowcasting: further development and application to Japan

*Kazuyoshi Nanjo[1], John B. Rundle[2], Tetsuo Sakurada[3]

1. University of Shizuoka, 2. University of California at Davis, 3. SAKURADA&Company

We adopted and further developed the earthquake nowcasting method (Rundle et al., 2016). This method determines the current state of the fault system in a predefined region and its current level of progress through the earthquake cycle, using only empirical data: magnitudes (M) and times of earthquakes in the region. The characteristic is that the method does not involve any model other than the idea of an earthquake cycle. We performed a case study from southern Kanto, using the earthquake catalog maintained by Japan Meteorological Agency (JMA). Two earthquake magnitudes are selected, one large ($M \geqq M_L$), and one small ($M \geqq M_S$), where $M_L > M_S$. The method utilizes the number of small earthquakes that occurs between pairs of large earthquakes. The cumulative probability distribution of these values is obtained. The earthquake potential score (EPS), an index of the current level of the progress through the earthquake cycle, is defined by the “natural time”, the number of small earthquakes that has occurred since the last large earthquake, the point where this number falls on the cumulative probability distribution. For southern Kanto, we used earthquakes since 1926 with depths shallower than 150 km and set M_L=6.0 and M_S=4.2. The obtained result as of December 20, 2018 is EPS of 8%. This is interpreted as an indication that if a large (M6+) earthquake occurred on this date, the recurrence interval would be relatively short. Errors that arise from statistics-based estimation such as this must be considered so that we introduced the calculation of uncertainties to the earthquake nowcasting, using a bootstrap approach. Taking into account the contribution of these errors to the EPS calculations, we conclude that the earthquake nowcasting generates stable estimates of EPS for southern Kanto (Nanjo, 2018). To check the stability estimation for other regions, we computed EPS and its uncertainty for selected regions in Japan. We also discuss a technique of spatial mapping of EPS over the Japan’s mainlands. This technique allows us to move towards a full description of current EPS as a function of space, providing possible usability for ranking locations on the earthquake hazard.

Keywords: nowcasting, earthquake, natural time

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[E] Poster | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_6

[S-SS05] Induced and triggered seismicity: case-studies, monitoring and modeling techniques

convener:Luca Urpi(Swiss Seismological Service - ETH Zurich), Bogdan Enescu(Department of Geophysics, Kyoto University), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Francesco Grigoli(ETH-Zurich, Swiss Seismological Service)

Induced and triggered seismicity occurs in conjunction with human activities such as reservoir impoundments, mining operations, conventional and non-conventional hydrocarbon production, geothermal energy exploitation, wastewater disposal, CO2 sequestration and gas storage operations as well as volcanic and hydrogeological processes. The stability of faults is affected by external solicitations such as pore-pressure diffusion, relaxation effects as well as stress field perturbations related to mass and/or volume changes, dike intrusions and earthquake-earthquake interactions. A better understanding of the physical processes governing induced and triggered seismicity is important for the assess the risk of current and future industrial activities, including the geological disposal of nuclear waste.

The study of Induced and triggered seismicity is inherently an interdisciplinary problem, which requires the combination of seismological, hydrogeological, geodetic data and a wide range of modeling approaches. This session welcome contributions covering the analysis and modeling of induced and triggered seismicity at different spatial scales and environments.

Relevant topics to be presented include but are not limited to case-studies of induced and triggered seismicity, spatio-temporal variations of physical parameters (including stress, pressure and temperature changes), spatio-temporal patterns of seismicity, modeling and risk mitigation strategies.

The goal of the session is to cover both theoretical and experimental aspects of these topics.

[SSS05-P01] Harmonic seismic waves excited by far-field earthquakes

*Osamu Murakami[1] (1.Tono Rearch Institute of Earthquake Science, Association for the Development of Earthquake Prediction)

[SSS05-P02] **Dynamic triggering of microseismicity around Yunnan following the 2004 Sumatra and 2012 Indian Ocean Earthquakes**

*Lu Li[1], Baoshan Wang[1,4], Zhigang Peng[2], Danning Li[3] (1.Institute of Geophysics, CEA, 2.Georgia Tech, 3.Yunnan Earthquake Agency, 4.USTC)

[SSS05-P03] Megathrust-inducing azimuthal seismic anisotropy in local and regional crusts

*Tae-Kyung Hong[1], Junhyung Lee[1], Ilgoo Kim[1], Seongjun Park[1] (1.Department of Earth System Sciences, Yonsei University)

[SSS05-P04] **A Novel Method to Estimate Fracture Permeability: Combining microseismic observational data and reservoir engineering model**

*Meihua Yang[1,2], Yusuke Mukuhira[2], Takatoshi Ito[2] (1.State Key Laboratory of Oil and Gas Geology and Exploitation, Chendu University of Technology (China) , 2.Institute of Fluid Science, Tohoku University (Japan))

[SSS05-P05] Doublet Earthquake Triggering for the April 2014 Events in the Solomon Islands

*Calvin Luiramo Qwana[1], Masatoshi Miyazawa[2], James Mori[2] (1.Graduate School of Science, Kyoto University, 2.DPRI, Kyoto Univ.)

[SSS05-P06] Thermal pressurization in a deep geological repository as a possible mechanism for fault reactivation

*Luca Urpi[1], Antonio Pio Rinaldi[1], Jonny Rutqvist[2], Stefan Wiemer[1] (1.Swiss Seismological Service, ETH Zurich, Switzerland, 2.Energy Geosceinces Division, LBNL, USA)

Harmonic seismic waves excited by far-field earthquakes

*Osamu Murakami[1]

1. Tono Rearch Institute of Earthquake Science, Association for the Development of Earthquake Prediction

It was observed the very harmonic seismic waves with a period of 17 s after 09:30 (UT) on Nov. 11 in 2018, at the mostly seismic stations in the global broadband seismograph network. It is assumed that the hypocenter of the harmonic waves was off Mayotte Island in the northern Mozambique channels between the continent of Africa and Madagascar Island. The physical cause of these waves remains unclear.

In order to understand such characteristic seismic waves, I firstly calculated the running spectra from Nov. 1 to Nov. 20 in 2018, using the observed seismograms at the station, ABPO, operated by IRIS/IDA. This station is the nearest station from the assumed hypocenter among the stations of the global seismograph network. From these running spectra, I found that the harmonic waves excited by the near- and far-field earthquakes. There were 10 far-field earthquakes whose magnitudes were larger than 6, in this period. Because the depths of 3 earthquakes in these 10 earthquakes were deeper than 100 km, I considered the remaining 7 shallow earthquakes. I investigated 2 larger earthquakes than others. The first one occurred in Jan Mayen Island region on Nov. 9 in 2018 (Mw6.7, hereafter EQ-J2018), and the second one occurred in South Sandwich Islands region on Nov. 15 in 2018 (Mw6.4, EQ-S2018). There was another earthquake near EQ-J2018. It occurred on Aug. 20 in 2012 (Mw6.7, EQ-J2012). There were two similar earthquakes near EQ-S2018, occurred on Dec. 8 in 2010 (Mw6.3, EQ-S2010) and on May 10 in 2017 (Mw6.5, EQ-S2017). From the comparison of the observed seismic waves between the similar hypocenter earthquakes, I found that the amplitudes of the surface waves in the earthquakes in 2018 (EQ-J2018, EQ-S2018) were several times as much as the ones in the previous earthquakes (EQ-J2012, EQ-S2010, EQ-S2017), at some stations.

In this study, I will show the features of these harmonic waves and to discuss the possible mechanisms.

Keywords: harmonic seismic waves, Mayotte Island, surface waves

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Dynamic triggering of microseismicity around Yunnan following the 2004 Sumatra and 2012 Indian Ocean Earthquakes

*Lu Li[1], Baoshan Wang[1,4], Zhigang Peng[2], Danning Li[3]

1. Institute of Geophysics, CEA, 2. Georgia Tech, 3. Yunnan Earthquake Agency, 4. USTC

We conduct a systematic detection of microseismicity around Yunnan following the 2004 Mw9.1 Sumatra and 2012 Mw8.6 Indian Ocean earthquakes to better understand the physical mechanism of dynamic triggering. Based on seismicity analysis on China Earthquake Network Center (CENC) catalog and spectral analysis of continuous waveforms, we find clear evidence of triggered seismicity in Yunnan immediately after the 2004 mainshock and a lack of instantaneous triggering following the 2012 mainshock. We further apply a matched filter technique to detect microearthquakes in Tengchong volcanic region 15 days before and 15 days after the 2012 mainshock. The seismicity rate remains stable immediately after the 2012 mainshock, and increases in the next few days, indicating a possible delayed triggering. In addition, we find possible evidence of remote triggering near the city of Yibin in Southern Sichuan Province, near the sites with ongoing shale gas development. We also examine other magnitude > 8 earthquakes from the Sumatra region and do not find any additional evidence of dynamic triggering around Yunnan. We suggest that the absolute value of dynamic stress change is the most important factor to explain why the 2004 Sumatra event triggered a widespread seismicity rate increase around Yunnan, while other great events around Sumatra did not.

Keywords: dynamic triggering, dynamic stress changes, Yunnan region

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Megathrust-inducing azimuthal seismic anisotropy in local and regional crusts

*Tae-Kyung Hong[1], Junhyung Lee[1], Ilgoo Kim[1], Seongjun Park[1]

1. Department of Earth System Sciences, Yonsei University

Megathrust earthquakes produce large coseismic and postseismic lithospheric displacements. The 2011 M9.0 Tohoku-Oki megathrust earthquakes produced large displacements up to regional distances. The lithospheric displacements directing to the epicenter on the convergent plate boundary developed transient uniaxial tension field over the backarc lithospheres. The Vp/Vs changes display characteristic 2 theta azimuthal variations in the upper crust of the Japanese islands, ranging between -0.0458 and 0.0422. Large lateral variations in Vp/Vs changes suggest medium-dependent perturbation. The lower crust of the Korean Peninsula in distances of ~1300 km displayed coseismic velocity changes of 3 % after the megathrust earthquake. The Vp/Vsratios and seismic velocities recovered gradually over time. Peak Vp/Vs and seismic velocity changes were observed along paths subparallel or subperpendicular to the directions toward the megathrust earthquake. The azimuthal seismic anisotropy may have developed from preferential crack orientation and azimuthal lithostatic stress changes. It appears that recovery of the medium properties may take decades. A series of moderate-sized earthquakes occurred as a consequence of medium response to the temporal evolution of stress field in the Korean Peninsula.

Keywords: megathrust earthquake, crustal deformation, induced seismicity

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A Novel Method to Estimate Fracture Permeability: Combining microseismic observational data and reservoir engineering model

*Meihua Yang[1,2], Yusuke Mukuhira[2], Takatoshi Ito[2]

1. State Key Laboratory of Oil and Gas Geology and Exploitation, Chendu University of Technology (China) , 2. Institute of Fluid Science, Tohoku University (Japan)

Effective utilization of geothermal resources is crucial to realize a sustainable society. Geothermal resources are widely present in Japan and the western United States, and the usage of geothermal resources are gradually increasing with many efforts. Meanwhile, the exploration and exploitation of geothermal resources in China has gradually developed. One of the challenges in conventional/next generation geothermal development (Enhanced/Engineered Geothermal System: EGS) is to understand the hydraulic properties of the geothermal reservoir. We often attempt to measure the hydraulic property (permeability or diffusivity) by wellbore tests or by using indicators such as migration of microseismicity. However, these quantities are often interpreted as representative value of hydraulic property for entire reservoir. Meanwhile, geothermal fluid circulates or flows in the existing/nucleated fracture system where permeability varies depending on condition of each fractures. Geothermal fluid is extracted from those permeable fractures very locally throughout production well drilled into the specific part of reservoir. Therefore, we need to have the best estimates of permeability for each fracture (local permeability) beyond representative permeability (global permeability). In addition, it is important to consider how the hydraulic properties can be affected by changes in the state of stress in the subsurface. This information is beneficial for design of geothermal energy extraction system and understanding of hydrology in the reservoir.

In this paper, we propose a novel method to estimate permeability of each individual fractures which experience shear slip at hydraulic stimulation. The spatiotemporal distribution of reservoir fluid pressure will be estimated using microseismic data. Using a hydromechanical fractured reservoir model, we will invert for the shear-dilation enhanced permeability change that controls the evolution of pressure along fractures and faults.

The first step is to estimate pore pressure distribution with microseismic data from real EGS field and observe how pore pressure migrated within single fracture (Figure 1 left: coloured circles). Meanwhile, using the hydromechanical fractured reservoir numerical model, we simulate pore pressure distribution within one fracture of given permeability and evaluate the evolution of hydraulic properties during a stimulation treatment (Figure 1 right: coloured sold lines). Therefore, we can use parameters from observational data as input parameters into hydromechanical model and estimate the best permeability which explain observed pore pressure distribution. We will also simulate all microseismic clusters and estimate permeability of each fractures. Then analyse the fracture permeability distribution (permeability mapping) in the study area.

In this research, it is the first attempt to estimate local permeability for each fracture. So far, only global permeability can be estimated by wellbore test or microseismic data and this permeability is not effective for each fracture in subsurface. Information of local permeability is quite valuable for designing a sustainable energy extraction system. Local permeability information also brings the way to model the flow of geothermal fluid in the reservoir, which is important for long-term management of geothermal resources.

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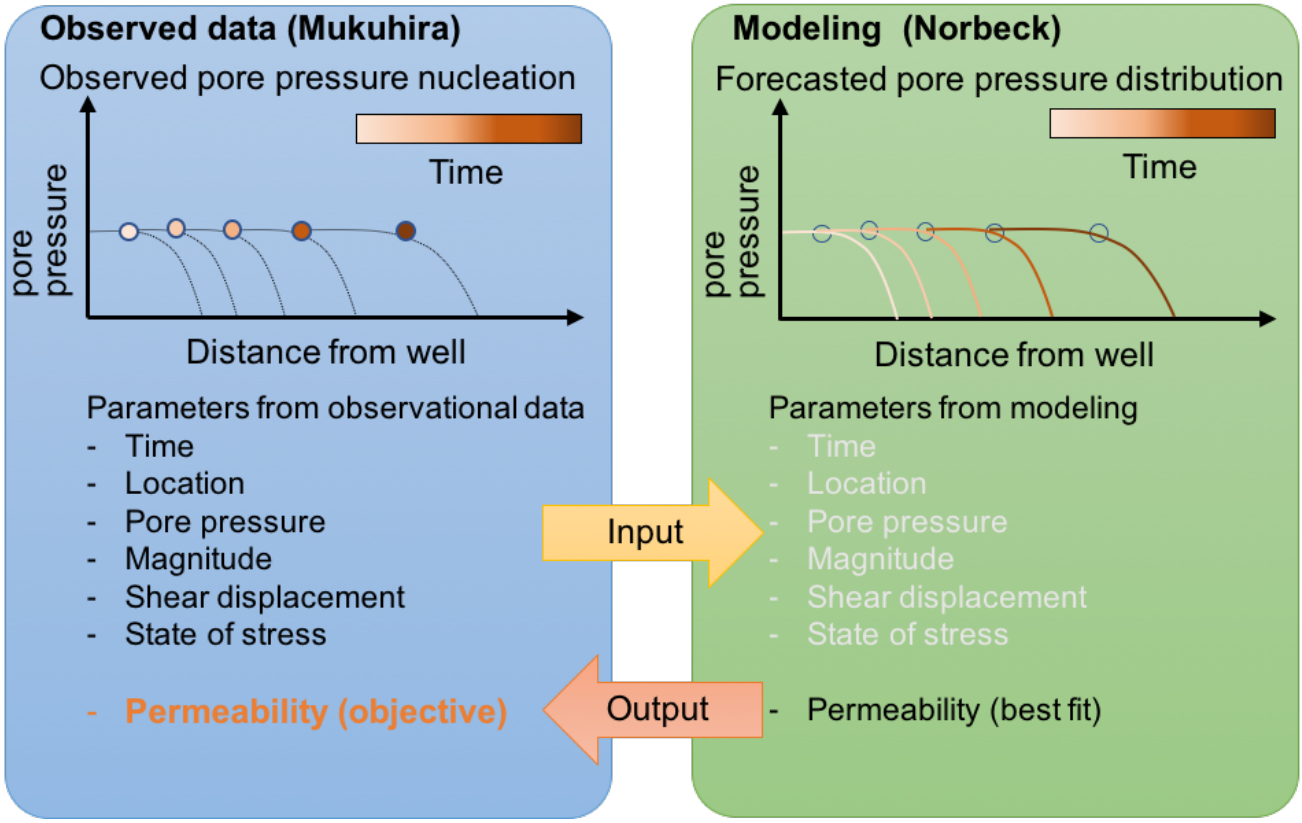
Keywords: Permeability, Microseismic, Reservoir engineering model



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Doublet Earthquake Triggering for the April 2014 Events in the Solomon Islands

*Calvin Luiramo Qwana[1], Masatoshi Miyazawa[2], James Mori[2]

1. Graduate School of Science, Kyoto University, 2. DPRI, Kyoto Univ.

In 2014 at 20:14 (UTC) on April 12th and 12:36 on April 13th, a doublet earthquake with moment magnitudes of M7.6 and M7.4, respectively occurred near Makira Island (San Cristobal) in the Solomon Islands. The depths of the events were 27 km and 37 km, respectively (GCMT). To understand the interrelation between the first (M7.6) and second (M7.4) events , we check the role of Coulomb stress triggering on aftershocks that follow the M7.6 main shock and the coulomb failure stress changes on both of the focal mechanism nodal planes for the second event. To understand if the coulomb stress triggering played a role in the evolution of the triggered event M7.4 earthquake, we evaluate the transient aftershocks from the M7.6 to see if it promoted failure on the rupture plane for the second event (M7.4). We evaluate the doublet source process of the events and recover the slip distribution on each of the faults. We use an iterative inversion method by Kikuchi and Kanamori (1991) for the teleseismic P waveforms recorded from more than 20 stations of the Global Seismographic Network in a distance range of 30˚ to 90˚. A fault plane with fixed strike and dip is placed in the region of the earthquake hypocenter and divided into subfaults, and a constant rupture velocity of 2.5 km/s is assumed. Synthetic waveforms are calculated at the teleseismic stations for dislocations at each subfault. Using the synthetic Green’ s functions, the observed seismograms are inverted to determine the fault plane and obtain the distribution of slips for the two events. The results show that the mechanism for the Mw7.6 first event is left-lateral strike-slip faulting for a plane of strike 116, dip 74 , and rake 24. The other NW-SE oriented nodal plane is almost parallel to Australian and Pacific plate boundary. Results for the mechanism of the Mw7.4 event indicates thrust faulting on fault plane oriented WNW –ESE with two possible nodal planes. The first plane (NP1) has strike 279, dip 46, rake 86 and the second (NP2)has strike 104, dip 44 and rake 94. The possibility for triggering the second event (M7.4) as influence by the main shock was examined in terms of the Coulomb failure stress function. The components of strain tensor were calculated by using the program DC3D (Okada, 1992). We calculated the changes in normal and shear stress and obtained a value for the Coulomb failure stress function of +148.5 kPa and +88.5 kPa at the hypocenter for NP1 and NP2, respectively. Both cases show increase of stress which encourages the likelihood of triggering on the recipient fault.

Keywords: Earthquake doublet , Triggering, Aftershock, Solomon Islands

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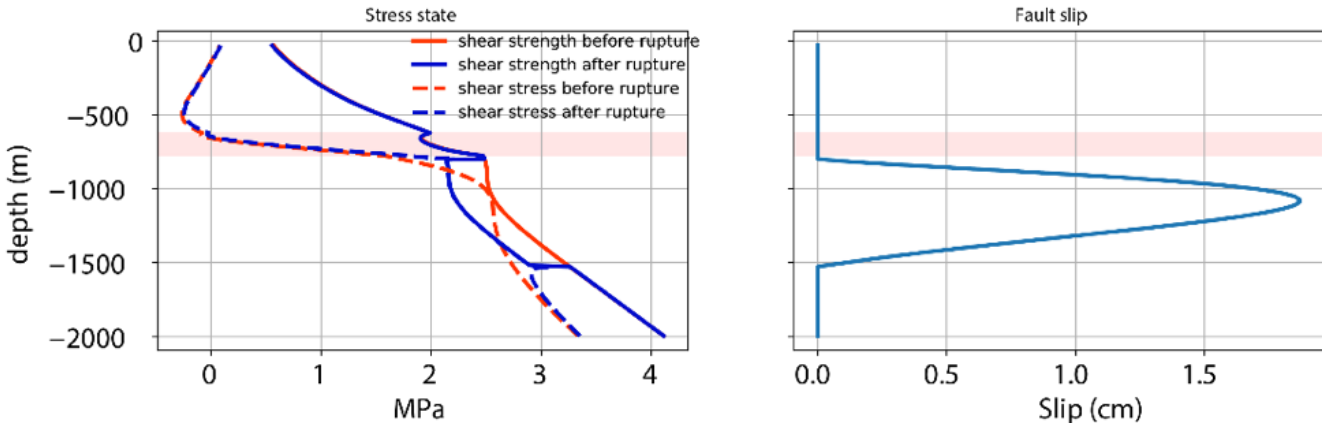
Thermal pressurization in a deep geological repository as a possible mechanism for fault reactivation

*Luca Urpi[1], Antonio Pio Rinaldi[1], Jonny Rutqvist[2], Stefan Wiemer[1]

1. Swiss Seismological Service, ETH Zurich, Switzerland, 2. Energy Geosceinces Division, LBNL, USA

A safe geological disposal site of radioactive waste requires identification of a rock formation that guarantees isolation to prevent unacceptable concentrations of radionuclides from migrating to the accessible environment. A common design for spent nuclear fuel disposal is the emplacement of specifically engineered canisters containing vitrified high-level radioactive waste (HLW) in a clay formation. The increase of temperature of a low permeability, fluid-saturated, media may trigger significant thermal pressurization, where the expansion of pore fluid cannot be accommodated by the thermal expansion of the pore space. With the aid of a coupled thermo-hydro-mechanical numerical simulator, we investigate the possible impact of thermal pressurization during the life of a deep geological repository on the stability of a nearby plane of weakness, assuming that the clay formation mantains its sealing properties. In our model, we represent the fault as a planar structure embedded in a thermo-poro-elastic material and shear activation evaluated by a strain-softening Mohr-Coulomb failure criterion. The results show that stress changes caused by temperature and thermal pressurization of a rock mass volume around the emplacement tunnels may trigger a slip event on a fault plane in proximity of the disposal site, with rupture nucleating at depth, hundreds of meter below the repository itself. We found that stress transfer plays an important role, while a direct hydraulic connection between the repository and the nucleation zone is not necessary in order to reach failure conditions. With a critical stress state (low horizontal to vertical stress ratio) the occurrence of slip may happen for a fault at a distance of up to 600m from the outermost tunnel. Intrinsic properties of the fault dictates the occurrence of seismic or aseismic slip, which may vary with depth. These results stress the need of investigating hydromechanical properties and local stress conditions to guarantee safe operations and predictable behavior of the HLW disposal site.

Keywords: Fault reactivation, thermal pressurization, stress transfer, deep geological repository high level storage, Rupture nucleation, Geomechanics



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[E] Poster | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_25

[S-SS05] Induced and triggered seismicity: case-studies, monitoring and modeling techniques

convener:Luca Urpi(Swiss Seismological Service - ETH Zurich), Bogdan Enescu(Department of Geophysics, Kyoto University), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Francesco Grigoli(ETH-Zurich, Swiss Seismological Service)

Induced and triggered seismicity occurs in conjunction with human activities such as reservoir impoundments, mining operations, conventional and non-conventional hydrocarbon production, geothermal energy exploitation, wastewater disposal, CO2 sequestration and gas storage operations as well as volcanic and hydrogeological processes. The stability of faults is affected by external solicitations such as pore-pressure diffusion, relaxation effects as well as stress field perturbations related to mass and/or volume changes, dike intrusions and earthquake-earthquake interactions. A better understanding of the physical processes governing induced and triggered seismicity is important for the assess the risk of current and future industrial activities, including the geological disposal of nuclear waste.

The study of Induced and triggered seismicity is inherently an interdisciplinary problem, which requires the combination of seismological, hydrogeological, geodetic data and a wide range of modeling approaches. This session welcome contributions covering the analysis and modeling of induced and triggered seismicity at different spatial scales and environments.

Relevant topics to be presented include but are not limited to case-studies of induced and triggered seismicity, spatio-temporal variations of physical parameters (including stress, pressure and temperature changes), spatio-temporal patterns of seismicity, modeling and risk mitigation strategies.

The goal of the session is to cover both theoretical and experimental aspects of these topics.

[SSS05-P01] Harmonic seismic waves excited by far-field earthquakes

*Osamu Murakami[1] (1.Tono Rearch Institute of Earthquake Science, Association for the Development of Earthquake Prediction)

[SSS05-P02] **Dynamic triggering of microseismicity around Yunnan following the 2004 Sumatra and 2012 Indian Ocean Earthquakes**

*Lu Li[1], Baoshan Wang[1,4], Zhigang Peng[2], Danning Li[3] (1.Institute of Geophysics, CEA, 2.Georgia Tech, 3.Yunnan Earthquake Agency, 4.USTC)

[SSS05-P03] Megathrust-inducing azimuthal seismic anisotropy in local and regional crusts

*Tae-Kyung Hong[1], Junhyung Lee[1], Ilgoo Kim[1], Seongjun Park[1] (1.Department of Earth System Sciences, Yonsei University)

[SSS05-P04] **A Novel Method to Estimate Fracture Permeability: Combining microseismic observational data and reservoir engineering model**

*Meihua Yang[1,2], Yusuke Mukuhira[2], Takatoshi Ito[2] (1.State Key Laboratory of Oil and Gas Geology and Exploitation, Chendu University of Technology (China) , 2.Institute of Fluid Science, Tohoku University (Japan))

[SSS05-P05] Doublet Earthquake Triggering for the April 2014 Events in the Solomon Islands

*Calvin Luiramo Qwana[1], Masatoshi Miyazawa[2], James Mori[2] (1.Graduate School of Science, Kyoto University, 2.DPRI, Kyoto Univ.)

[SSS05-P06] Thermal pressurization in a deep geological repository as a possible mechanism for fault reactivation

*Luca Urpi[1], Antonio Pio Rinaldi[1], Jonny Rutqvist[2], Stefan Wiemer[1] (1.Swiss Seismological Service, ETH Zurich, Switzerland, 2.Energy Geosceinces Division, LBNL, USA)

Harmonic seismic waves excited by far-field earthquakes

*Osamu Murakami[1]

1. Tono Rearch Institute of Earthquake Science, Association for the Development of Earthquake Prediction

It was observed the very harmonic seismic waves with a period of 17 s after 09:30 (UT) on Nov. 11 in 2018, at the mostly seismic stations in the global broadband seismograph network. It is assumed that the hypocenter of the harmonic waves was off Mayotte Island in the northern Mozambique channels between the continent of Africa and Madagascar Island. The physical cause of these waves remains unclear.

In order to understand such characteristic seismic waves, I firstly calculated the running spectra from Nov. 1 to Nov. 20 in 2018, using the observed seismograms at the station, ABPO, operated by IRIS/IDA. This station is the nearest station from the assumed hypocenter among the stations of the global seismograph network. From these running spectra, I found that the harmonic waves excited by the near- and far-field earthquakes. There were 10 far-field earthquakes whose magnitudes were larger than 6, in this period. Because the depths of 3 earthquakes in these 10 earthquakes were deeper than 100 km, I considered the remaining 7 shallow earthquakes. I investigated 2 larger earthquakes than others. The first one occurred in Jan Mayen Island region on Nov. 9 in 2018 (Mw6.7, hereafter EQ-J2018), and the second one occurred in South Sandwich Islands region on Nov. 15 in 2018 (Mw6.4, EQ-S2018). There was another earthquake near EQ-J2018. It occurred on Aug. 20 in 2012 (Mw6.7, EQ-J2012). There were two similar earthquakes near EQ-S2018, occurred on Dec. 8 in 2010 (Mw6.3, EQ-S2010) and on May 10 in 2017 (Mw6.5, EQ-S2017). From the comparison of the observed seismic waves between the similar hypocenter earthquakes, I found that the amplitudes of the surface waves in the earthquakes in 2018 (EQ-J2018, EQ-S2018) were several times as much as the ones in the previous earthquakes (EQ-J2012, EQ-S2010, EQ-S2017), at some stations.

In this study, I will show the features of these harmonic waves and to discuss the possible mechanisms.

Keywords: harmonic seismic waves, Mayotte Island, surface waves

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Keywords: dynamic triggering, dynamic stress changes, Yunnan region

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Megathrust-inducing azimuthal seismic anisotropy in local and regional crusts

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Keywords: megathrust earthquake, crustal deformation, induced seismicity

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A Novel Method to Estimate Fracture Permeability: Combining microseismic observational data and reservoir engineering model

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The first step is to estimate pore pressure distribution with microseismic data from real EGS field and observe how pore pressure migrated within single fracture (Figure 1 left: coloured circles). Meanwhile, using the hydromechanical fractured reservoir numerical model, we simulate pore pressure distribution within one fracture of given permeability and evaluate the evolution of hydraulic properties during a stimulation treatment (Figure 1 right: coloured sold lines). Therefore, we can use parameters from observational data as input parameters into hydromechanical model and estimate the best permeability which explain observed pore pressure distribution. We will also simulate all microseismic clusters and estimate permeability of each fractures. Then analyse the fracture permeability distribution (permeability mapping) in the study area.

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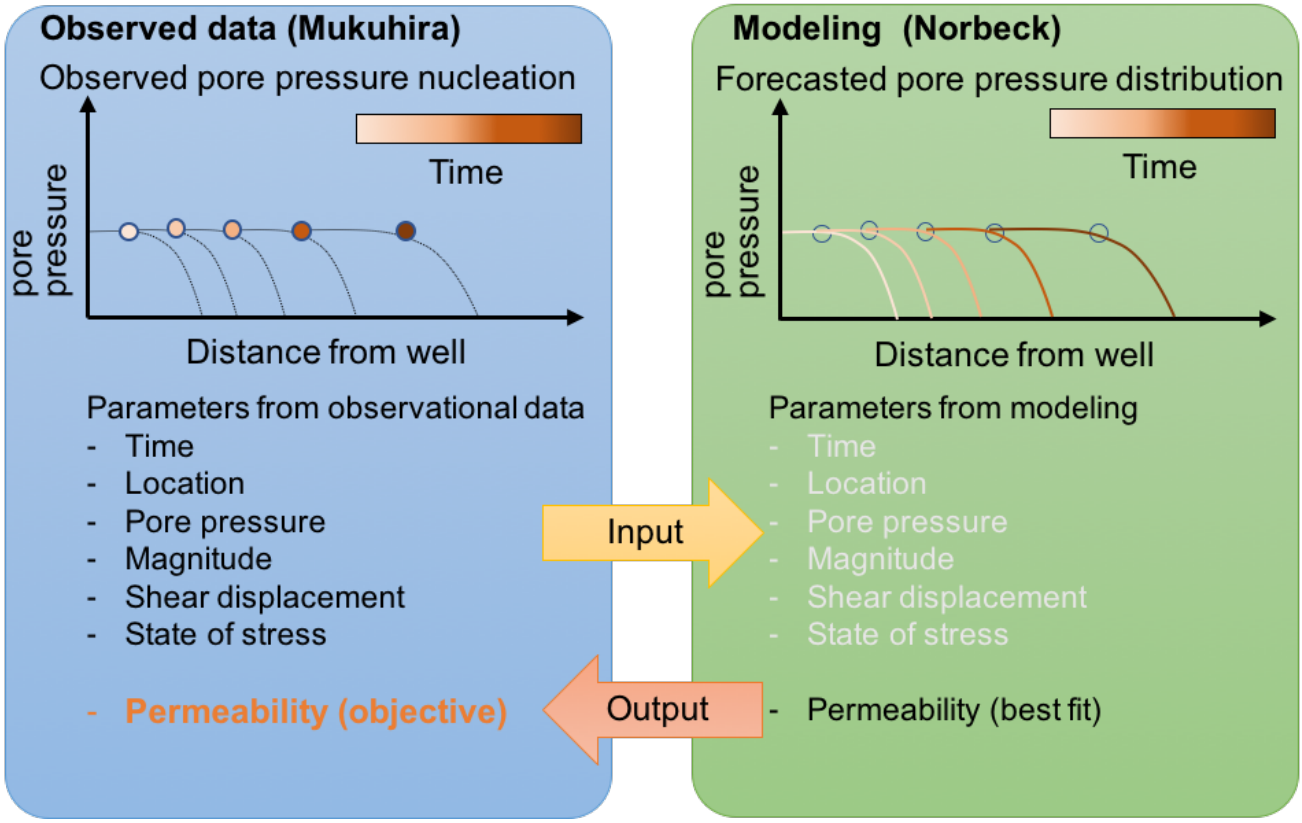
Keywords: Permeability, Microseismic, Reservoir engineering model



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Thermal pressurization in a deep geological repository as a possible mechanism for fault reactivation

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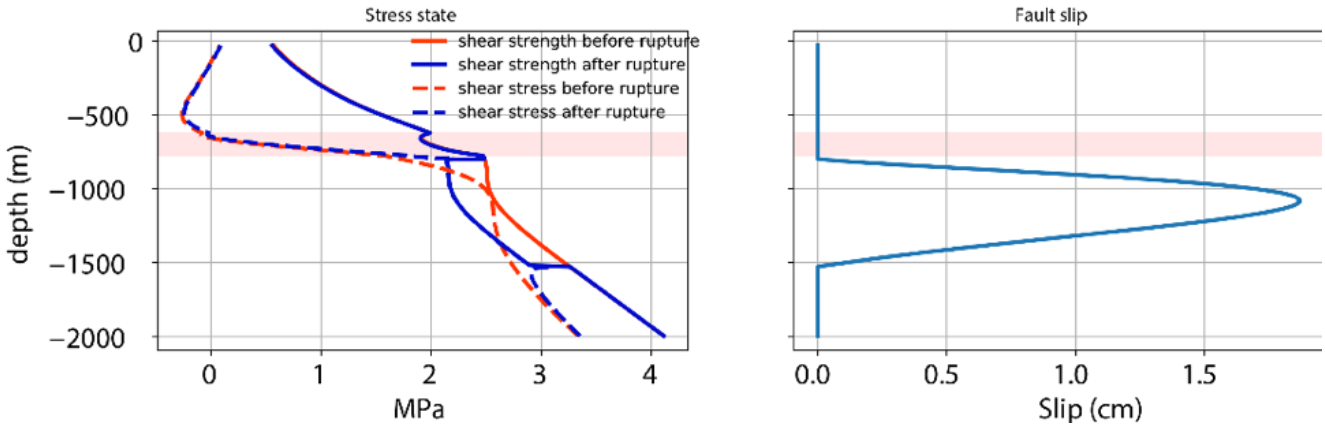
Keywords: Fault reactivation, thermal pressurization, stress transfer, deep geological repository high level storage, Rupture nucleation, Geomechanics



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[E] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[S-SS05] Induced and triggered seismicity: case-studies, monitoring and modeling techniques

convener:Luca Urpi(Swiss Seismological Service - ETH Zurich), Bogdan Enescu(Department of Geophysics, Kyoto University), Yosuke Aoki(Earthquake Research Institute, University of Tokyo), Francesco Grigoli(ETH-Zurich, Swiss Seismological Service), Chairperson:Luca Urpi(ETH-Zurich; Swiss Seismological Service), Bogdan Enescu(Graduate Schoold of Science, Kyoto University), Francesco Grigoli(ETH-Zurich; Swiss Seismological Service), Yosuke Aoki

Induced and triggered seismicity occurs in conjunction with human activities such as reservoir impoundments, mining operations, conventional and non-conventional hydrocarbon production, geothermal energy exploitation, wastewater disposal, CO2 sequestration and gas storage operations as well as volcanic and hydrogeological processes. The stability of faults is affected by external solicitations such as pore-pressure diffusion, relaxation effects as well as stress field perturbations related to mass and/or volume changes, dike intrusions and earthquake-earthquake interactions. A better understanding of the physical processes governing induced and triggered seismicity is important for the assess the risk of current and future industrial activities, including the geological disposal of nuclear waste.

The study of Induced and triggered seismicity is inherently an interdisciplinary problem, which requires the combination of seismological, hydrogeological, geodetic data and a wide range of modeling approaches. This session welcome contributions covering the analysis and modeling of induced and triggered seismicity at different spatial scales and environments.

Relevant topics to be presented include but are not limited to case-studies of induced and triggered seismicity, spatio-temporal variations of physical parameters (including stress, pressure and temperature changes), spatio-temporal patterns of seismicity, modeling and risk mitigation strategies.

The goal of the session is to cover both theoretical and experimental aspects of these topics.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS05-01] Causality between induced seismicity b-value reduction and stress state of existing fractures

★Invited Papers

*Yusuke Mukuhira[1], Michael C Fehler[2], Takatoshi Ito[1], Hiroshi Asanuma[3], Markus O Häring[4] (1.Institute of Fluid Science, Tohoku University, 2.ERL, Massachusetts Institute of Technology , 3.FREA, AIST, 4.Häring GeoProject)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS05-02] Micromechanical model connecting earthquake statistics and observed spatiotemporal changes in source parameters of fluid induced seismicity

*Daisuke Sato[1], Keisuke Yoshida[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Tohoku University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS05-03] Seismicity induced by Multi-cycle operation of Hutubi underground gas storage, Xinjiang, China

*Baoshan Wang[1,2], Bo Zhang[2], Zhanbo Ji[2], Jinxin Hou[2], Lu Li[2] (1.University of Science and Technology of China, 2.Institute of Geophysics, China Earthquake Administration)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS05-04] Investigating the origin of the Mw 5.4 Pohang, Korea, earthquake of November 15, 2017: the investigations and conclusions of the Overseas Research Advisory Committee (ORAC)

*Toshihiko Shimamoto[1], William Ellsworth[2], Shermin Ge[3], Domenico Giardini[4], John Townend[5] (1. Institute of Geology, China Earthquake Administration, 2.Stanford University, 3.University of Colorado Boulder, 4.ETH, Zurich, 5.Victoria University of Wellington)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS05-05] **Seismic Anisotropy Measured before and after the 2016 Kumamoto and Kaikoura earthquakes**

*Martha K Savage[1], Kenny Graham[1], Yosuke Aoki[2], Richard Arnold[1], Tomomi Okada[3], Yoshihisa Iio[4], Satoshi Matsumoto[5] (1.Victoria University of Wellington, 2.Earthquake Reserach Institute, University of Tokyo, 3.Tohoku University, Sendai 980-8578, Japan, 4.Kyoto University, Uji 611-0011, Japan, 5.Kyushu University, 2-5643-29 Shin'yama, Shimabara, Nagasaki, 855-0843, Japan)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS05-06] Long-term behavior of induced seismicity in the Val d'Agri basin (Southern Apennines, Italy).

★Invited Papers

*Luisa Valoroso[1], Luigi Improta[1], Samer Bagh[1], Davide Piccinini[1], Pasquale De Gori[1] (1.Istituto Nazionale di Geofisica e Vulcanologia)

Causality between induced seismicity b-value reduction and stress state of existing fractures

*Yusuke Mukuhira[1], Michael C Fehler[2], Takatoshi Ito[1], Hiroshi Asanuma[3], Markus O Häring[4]

1. Institute of Fluid Science, Tohoku University, 2. ERL, Massachusetts Institute of Technology , 3. FREA, AIST, 4. Häring GeoProject

The Gutenberg–Richter distribution of earthquakes is a power law relationship and it holds for laboratory scale earthquakes (acoustic emission) to subduction zone earthquakes as well as induced seismicity. The gradient of the power law is known as the b-value, which can be considered the ratio of the number of the larger earthquakes to small ones. Larger earthquakes are often observed in low b-value regions, or alternatively a b-value reduction has been observed before some main shocks. Some authors have argued that b–value is negatively correlated with differential stress level. Therefore, a b-value anomaly found in time-space analysis may be used for detection of an area of stress concentration and used for earthquake prediction or hazard risk assessment.

In the field of induced seismicity where b-value reduction has also been observed, the physical mechanism of b-value reduction has not been well understood. Since induced seismicity related with fluid injection usually occurs at depths around 1000 ~ 5000 m, a significant tectonic loading to cause a stress change during the short time period of a hydraulic stimulation might not be expected. We used borehole analysis and focal mechanism information to investigate the stress state on the existing fractures that caused induced seismicity. Then we divide the catalog into the groups with varying normalized shear stress threshold and estimated the b-value. We found that b-value for the events that occurred along higher shear stress fractures were significantly lower (figure 1a) than those from the moderate/lower shear stress fractures (figure 1b). Thus, b-value dependency on the shear stress can be observed for induced seismicity on a reservoir scale. Therefore, we propose that the reason for the observed b-value reductions in induced seismicity on a reservoir scale is the events that occur along higher shear stress fractures. Supposing that the earthquakes occur along well-orientated fractures, the b-value dependence on differential stress can be translated to dependence on shear stress. Thus, our observations about b-value are consistent with the conventional interpretations of b-value.

Keywords: b-value, Shear stress, induced seismicity

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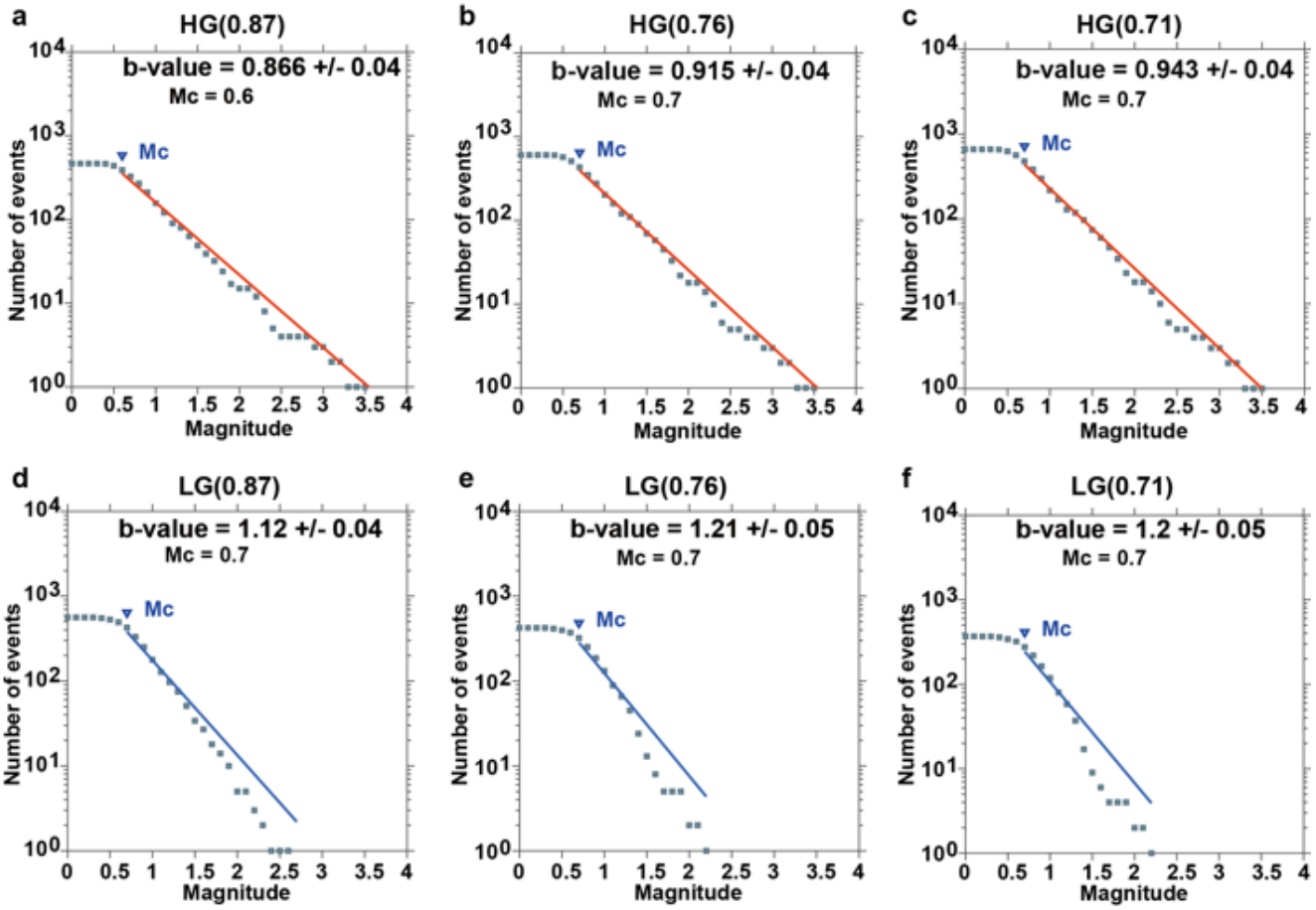

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Micromechanical model connecting earthquake statistics and observed spatiotemporal changes in source parameters of fluid induced seismicity

*Daisuke Sato[1], Keisuke Yoshida[2]

1. Disaster Prevention Research Institute, Kyoto University, 2. Tohoku University

In the context of the hazard assessment of fluid-induced seismicity, the earthquake activities are known to successively continue even after the stop of fluid-injection. The change in earthquake statistics (typified by b-values and seismicity rate) is shown to be the functions of elapsed time from fluid injection similar to the Omori-law of aftershocks, even without any mainshocks (Bachmann et al., 2012). Such statistical features are also seen in the natural earthquake swarms, and simultaneously, it is further shown that the corresponding change of the stress-strength state can be captured by using source parameters (such as stress drops, strength) (Yoshida et al., 2017). The model is now required to describe synchronized observed changes in the source parameters and earthquake activities (Segall and Lu, 2015).

In this research, by considering strength heterogeneity of faults expected from experimentally verified physics, we provide the micromechanical model of such seismicity induced by on-fault fluid diffusion, and explain the results of the above data-driven analysis. Presentation contains following four contents. First, a micromechanical model is proposed. In the model, many patches are distributed randomly on a fault so that the patches are sufficiently small (or distant) to interact with each other; those patches rupture when the effective strength becomes smaller than applied shear stress due to the fluid diffusion, and the rupture cascades in each patches as in Scholz (1965). The assumption of the on-fault diffusion is based on the recent observation that the earthquake activities propagate facially (e.g., Yukutake et al., 2010, Yoshida et al., 2017). Second, the spatiotemporal changes of the source parameters are obtained as the solutions of the model. Consequently, multiple source parameters are parametrized by injected pressure, diffusion radius of fluid, normal stress on the fault, and the fluctuation of the excess strength; after the parametrization, those source parameters are shown to follow the common master curve. Third, the observed data is fitted, and the consistency between the theory and the observation is suggested. Fourth, the theoretical prediction for the temporal transience in the moment release rate is checked by the data of Yoshida et al. (2017), and the result strongly supports the theory.

Keywords: Induced-Seismicity and Earthquake Swarms, Micromechanical Model, Source Paraemters

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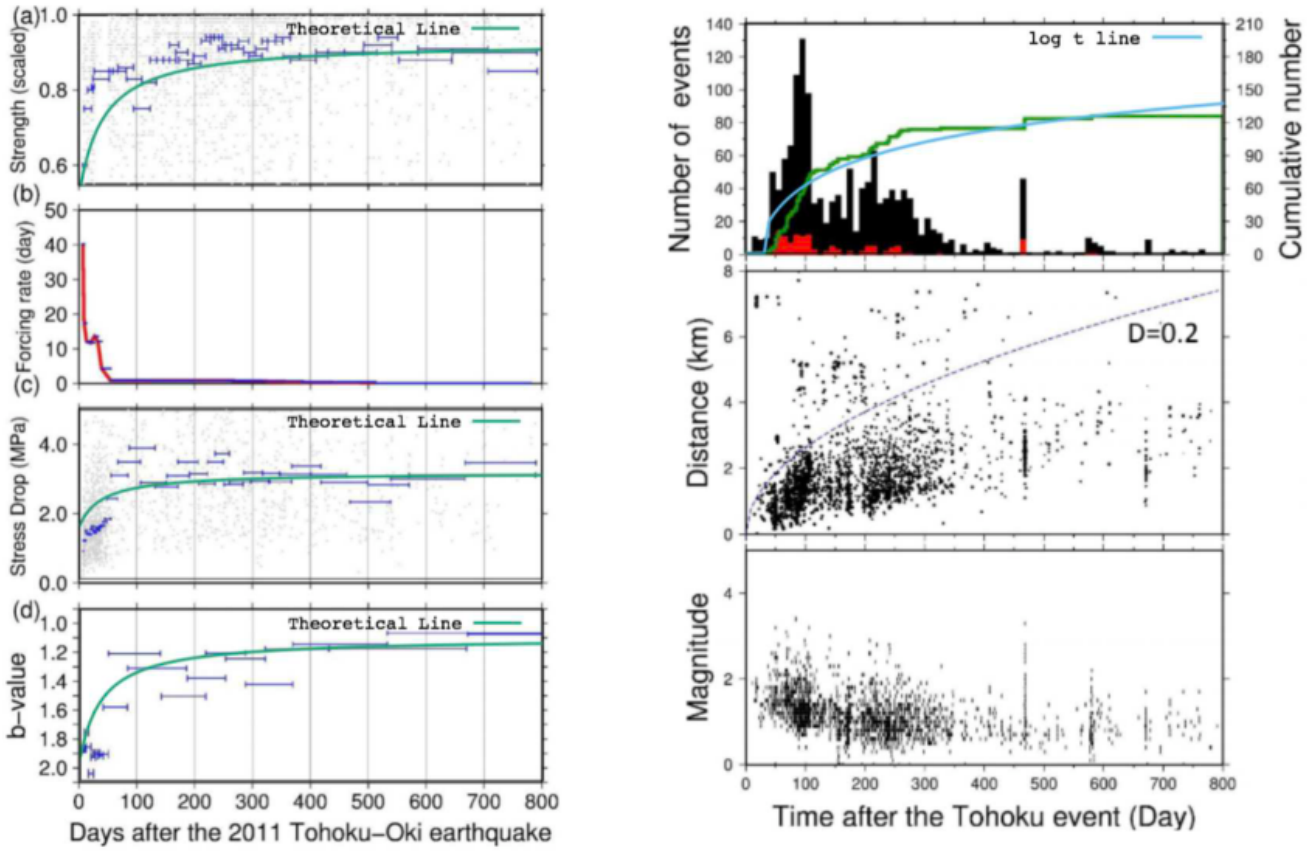

Yoshida et al. (2017)

Fig. 1. A data example of Yoshida et al. (2017) fitted by our theoretical model (written as theoretical or log t line in the figure), after Yoshida et al (2017). (Left) Temporal evolution of the source paramters. (Right) Number of events and the spatial patterns of the seismicity.

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Seismicity induced by Multi-cycle operation of Hutubi underground gas storage, Xinjiang, China

*Baoshan Wang[1,2], Bo Zhang[2], Zhanbo Ji[2], Jinxin Hou[2], Lu Li[2]

1. University of Science and Technology of China, 2. Institute of Geophysics, China Earthquake Administration

In 2013, one of the largest UGSs in China, the Hubuti UGS started to operate in Xinjiang, northwestern China. To monitor the seismicity near the Hutubi UGS and adjacent area, we deployed 36 portable broadband 3-component seismic stations, complementing four permanent seismic stations within 100 km from the Hutubi UGS. We calibrate the 1-D model with the active source record and relocated the events which are used as template to search for the missed events with the Match and Located method. In the period of January 2013 to December 2017, we detected and located more than 3000 earthquakes, 5 times more than the catalog. Our results suggest a possible correlation of seismicity and the gas injection/extraction process, and it is spread to 10-20 km in the last two cycles. Control the rate of gas injection and extraction can reduce the risk from seismic events.

Keywords: Underground Gas Storage, Multi-cycle operation, Induced Seismicity

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Investigating the origin of the Mw 5.4 Pohang, Korea, earthquake of November 15, 2017: the investigations and conclusions of the Overseas Research Advisory Committee (ORAC)

*Toshihiko Shimamoto[1], William Ellsworth[2], Shermin Ge[3], Domenico Giardini[4], John Townend[5]

1. Institute of Geology, China Earthquake Administration, 2. Stanford University, 3. University of Colorado Boulder, 4. ETH, Zurich, 5. Victoria University of Wellington

On November 15, 2017 a Mw 5.4 earthquake struck the city of Pohang, Republic of Korea, causing numerous injuries and in excess of $50 million in damage. Initial estimates of the location of the earthquake placed it near an enhanced geothermal systems (EGS) project that was still under development. The proximity of the earthquake to the project raised question about the possible association between industrial activities and the earthquake, and also led to the termination of the project. The Pohang EGS project was developing a geothermal reservoir by high-pressure hydraulic injection into a pair of wells at depths in excess of 4 km in the crystalline basement. The goal was to create a permeable pathway between the boreholes for the extraction of heat for the production of electricity. As part of the official government investigation into the earthquake, the Geological Society of Korea (GSK) formed an Overseas Research Advisory Committee (ORAC) charged with conducting a comprehensive investigation of the earthquake and any potential involvement of the Pohang EGS project in its origin. Investigations included the analysis of both natural seismicity and earthquakes induced during stimulation of the wells, development of mechanical and hydrogeologic models of the stimulations and comprehensive review of relevant drilling and stimulation data. As part of their investigation, the ORAC has been working closely with university researchers and with the full cooperation of government agencies and the EGS project. The summary report by the GSK and the ORAC will be released in March 2017. This presentation will summarize the findings of the ORAC investigation.

Keywords: Pohang earthquake, Korea, induced earthquake, triggered earthquake

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Seismic Anisotropy Measured before and after the 2016 Kumamoto and Kaikoura earthquakes

*Martha K Savage[1], Kenny Graham[1], Yosuke Aoki[2], Richard Arnold[1], Tomomi Okada[3], Yoshihisa Iio[4], Satoshi Matsumoto[5]

1. Victoria University of Wellington, 2. Earthquake Reserach Institute, University of Tokyo, 3. Tohoku University, Sendai 980-8578, Japan, 4. Kyoto University, Uji 611-0011, Japan, 5. Kyushu University, 2-5643-29 Shin'yama, Shimabara, Nagasaki, 855-0843, Japan

Seismic anisotropy in the crust may be caused by stress that aligns microcracks, strain that aligns minerals or structural effects. Recently both anisotropic and isotropic velocity changes have been determined after large earthquakes, and are often considered to be related to cracks that heal with time. In 2016, large earthquakes in Japan (April, Kumamoto, Kyushu) and in New Zealand (November, Kaikoura) caused widespread disruption, and also produced data with which to test some of these theories. Here we use shear wave splitting to study the seismic anisotropy before and after the 2016 Kumamoto and the Kaikoura earthquakes to study the phenomena.

In Kyushu, measurements from NIED stations between 2004-2012 yielded fast anisotropic directions that align well on average with the maximum horizontal stress from focal mechanism inversions and the maximum horizontal strain rate as measured by the GNSS system. We measured shear wave splitting on these same stations during 2016 to determine whether shear wave splitting changed over time after the Kumamoto earthquake. A few stations yielded different fast directions or increases in delay times. We are checking whether those changes are due to structural changes or can be explained by changing earthquake locations.

In New Zealand, we have measured shear wave splitting and Vp/Vs ratios on permanent stations near the Kaikoura earthquake rupture region between 2013 and 2018. Some stations exhibit apparent changes in fast direction, but spatial averaging does not yield strong changes in fast directions with time. Delay times and Vp/Vs ratios both increased after the M=6.5 and M=6.6 Cook Strait earthquakes and after the M=7.8 Kaikoura earthquake. After the Cook Strait earthquakes, measurements returned to background levels within several months. But by the end of 2017 the measurements had not yet returned to normal. Laboratory measurements suggest that crack healing should yield more rapid recovery, and we are exploring whether aftershocks help to keep the cracks open.

Keywords: Anisotropy, Vp/Vs, Kumamoto, Kaikoura, temporal variation, Shear wave splitting

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Long-term behavior of induced seismicity in the Val d’ Agri basin (Southern Apennines, Italy).

*Luisa Valoroso[1], Luigi Improta[1], Samer Bagh[1], Davide Piccinini[1], Pasquale De Gori[1]

1. Istituto Nazionale di Geofisica e Vulcanologia

The Val d’ Agri (VA) basin in the southern Apennines seismic belt is one of the regions in the central Mediterranean with highest seismogenic potential, testified by a M7+ historical earthquake in 1857. In the past forty years, the Val d’ Agri basin only experienced weak background seismicity (M_{max} 3.2). This background activity coexists with two well-documented cases of anthropogenic seismicity. The first case is related to the operation of the largest onshore oilfield in Europe, hosted in a high productive reservoir formed by naturally fractured, low-porosity carbonates. Hydrocarbons are currently extracted through 22 wells from 1.8 to 3.5 km depth below sea level. Extraction started in the mid-1990 and present-day oil production rates 80,000–90,000 barrel (bbl)/d with 2.6 x 10^5 m^3/d of associated gas. Due to a low primary porosity of the reservoir rocks, production is controlled by fracture systems at various scales. Since 2006, co-produced saltwater is re-injected at 3 km depth in the Costa Molina 2 (CM2) well located at a marginal portion of the carbonate reservoir, with injection rate and well-head pressure reaching maximum values of 2800–3000 m3/d and 13–14 MPa, respectively, inducing well-documented microseismicity (M_{max}2). The wastewater injection, which started on June 1st 2006, has continued since then without major interruptions. The second case of antropogenic induced seismicity includes M3+ swarms that have been associated to the medium-sized Pertusillo water reservoir (PWR) characterized by seasonal water-level oscillation as high as 40 m, corresponding to storage changes of about 110 million m^3. In this work, we show a comprehensive analysis of the spatiotemporal seismicity distribution in the Val d’ Agri area, by using data collected during the 2001-2014 by integrating three different permanent and temporary dense networks. Due to the presence of continuously recording permanent stations run by INGV, we also used cross-correlation (CC) matched filter technique to look for undetected earthquakes with the aim to decrease the completeness magnitude of the available seismicity catalogue. Seismicity data have been used to compute high-precision seismicity locations by integrating cross-correlation and double-difference methods and to reconstruct the detailed three-dimensional Vp and Vp/Vs tomography structure of the area. The properties of the carbonate reservoir (rock fracturing, pore fluid pressure) and inherited faults control the occurrence and spatiotemporal distribution of seismicity. For the CM2 wasterwater injection-linked seismicity, the comprehensive picture obtained by integrating reservoir-scale tomography, high-precision earthquake locations, and geophysical and injection data suggests that the driving mechanism is the channeling of pore pressure perturbations through a high permeable fault damage zone within the reservoir. Analogously, the combined interpretation of the spatiotemporal seismicity distribution with the velocity structure the PWR induced seismicity, suggests that the observed seismicity migration can be caused by poroelastic deformation of the fractured water-bearing carbonates in response to the seasonal loading of the PWR.

Keywords: induced seismicity , fault zone structure, velocity model , high-precision earthquake locations

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Yoshinari Hayashi(Faculty of Safety Science, Kansai University), Dianshu Ju(Ohsaki Research Institute, Inc.)

Strong ground motion has social impacts as it induces earthquake disasters. We solicit contribution on any seismological topics related to strong ground motion that includes, but are not limited to, source processes, wave propagation, and site effects. We also welcome contribution on earthquake related disaster mitigation.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SSS13-01] Investigation of the effect of jog deviations on Riedel fractures by three-dimensional elasto-plastic analysis

*Tomohiro Toyoda[1], Toshihiro Noda[2], Shotaro Yamada[1], Akira Asaoka[3] (1.Nagoya University, Graduate School of Engineering, 2.Nagoya University, Disaster Mitigation Research Center, 3.Association for the development of earthquake prediction)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SSS13-02] A survey on earthquake prediction and public warning in seismological community

*Yoshinari Hayashi[1] (1.Faculty of Societal Safety Sciences, Kansai University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SSS13-03] Long-period strong ground motion of the Tokyo Bay area during the events occurred in the plate triple junction area

*Tomiichi Uetake[1] (1.R&D Department, TEPCO research Institute, Tokyo Electric Power Company)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS13-04] Time-frequency and engineering characteristics on offshore ground motion

*CHEN Su[1], FU Lei[1], LI Xiaojun[1] (1.Institute of Geophysics, China Earthquake Administration)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS13-05] Long-period Ground Motion from Hypothetical Megathrust Earthquakes along the Nankai Through using the Ambient Seismic Field

*Loic Viens[1], Tomotaka Iwata[1] (1.Disaster Prevention Research Institute, Kyoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS13-06] Fault model and strong ground motion evaluation for the Nankai megathrust earthquake

*Dianshu Ju[1], Hiroyuki Fujiwara[2], Nobuyuki Morikawa[2] (1.Ohsaki Research Institute, Inc., 2.National Research Institute for Earth Science and Disaster Resilience)

Investigation of the effect of jog deviations on Riedel fractures by three-dimensional elasto-plastic analysis

*Tomohiro Toyoda[1], Toshihiro Noda[2], Shotaro Yamada[1], Akira Asaoka[3]

1. Nagoya University, Graduate School of Engineering, 2. Nagoya University, Disaster Mitigation Research Center, 3. Association for the development of earthquake prediction

The Riedel fracturing process is strongly affected by the presence of jogs. For example, Fig. 1 describes left strike-slip fault with discontinuity of fault zone. The jog on the far side will be expanded with an accumulation of fault displacement and it causes depression of the ground surface as shown in Fig. 2(a), whereas the jog on the front side will be compressed and it causes bulge of the ground surface in Fig. 2(b). These transtensional/transpressional deformation fields called pull-apart/push-up are under the pure shear on which the tension/compression is superposed due to the presence of jogs. Authors have conducted three-dimensional elasto-plastic finite deformation analysis considering jogs of pull-apart and push-up as boundary conditions to numerically obtain the Riedel fracturing process. The abstract especially reports numerical investigations on the effects of the jog deviation on the angle of Riedel shears with principal stress rotation.

Simulations are implemented with the dynamic/static soil-water coupled elasto-plastic finite deformation analysis code ***GEOASIA***. Although the analysis code can accommodate two-phase analysis, only the one-phase analysis is carried out in the abstract. Finite element mesh with consideration of bending fault zone is shown in Fig. 3. Material parameters for SYS Cam-clay model are conformed to the preceding study[2)]. We prepared three models whose length is equal/doubled/tripled to the model in the *y*-direction (α=1, 2, 3). The analysis is conducted parametrically changing the jog deviation *d*=5, 10, 15mm. Figure 4 indicates shear strain distributions at the end of the simulations. The right diagonal Riedel shear band are obtained as a result of shear strain localization.

As for the results of *d*=15mm, the duplexing fracture patterns are obtained on the push-up side (α=1) whilst the P-shears are obtained on the pull-apart side (α=2, 3). However these fracturing patterns could no longer be detected in the cases of *d*=10, 5 mm. Especially in the case of *d*=5mm, only the independent single shears appear on the surface. The result suggests the significance of the installation of jogs to simulate these secondary fractures.

Focusing on the angle of Riedel shears on the tripled scale model α=3, there' s no difference in terms of fracture angles between the push-up and the pull-apart sides. However, the increase of a jog deviation makes Riedel shear angle lower/higher against the strike-slip running direction on the push-up/pull-apart side. It can actually be understood by the change of the principal stress direction. Figure 5 indicates the direction of maximum principal stress on the Riedel fractures above the regions A and B shown in Fig. 3 at the end of calculations, where the clockwise angle against running direction is positive. Because the direction of maximum principal stress in a pure sheared zone (straight fault zones without jogs) should be 45° in general, the angle deviation from 45° can be regarded as a result of jog installation. The figure indicates that the angle of the maximum principal stress become larger/smaller than 45° on the push-up/pull-apart side under transpressional/transtensional stress distribution. However, these transpressional/transtensional stress distribution gradually turn into pure shear with the decrease of a jog deviation. Therefore, the small difference of fracture angle between the push-up and the pull-apart sides with small jog deviation can be understood as a consequence of the increased percentage of pure shear in transpression/transtension.

(Acknowledgement) Numerical simulations in this paper are conducted by utilizing a supercomputer

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system in Kyoto University, Japan. And we received Grant-in-Aid for Scientific Research (Grant-in-Aid for Scientific Research (A): No. 17H01289).

1) Fossen, H. (2016): Structural Geology, Cambridge University Press, pp.377-400, 2nd edition.
2) Noda, T., et al. (2008): Soil-water coupled finite deformation analysis based on a rate-type equation of motion incorporating SYS Cam-clay model, S&F, Vol.48, No.6, pp.771-790.
3) Toyoda et al. (2018): Simulation of Riedel shear bands considering strong non-linearity of ground and geometrical barrier on strike-slip fault, JpGU2018, SCG66-05.

Keywords: strike-slip fault, Riedel shear, jog, elasto-plasticity, numerical analysis, fracture

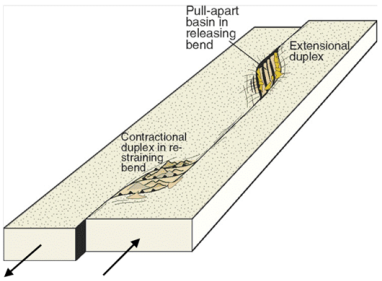

Fig. 1 Jog on strike-slip fault[1)]

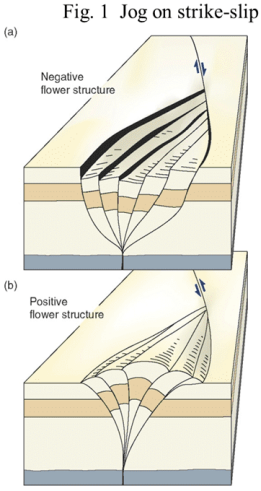

Fig. 2 Flower structures[1)]

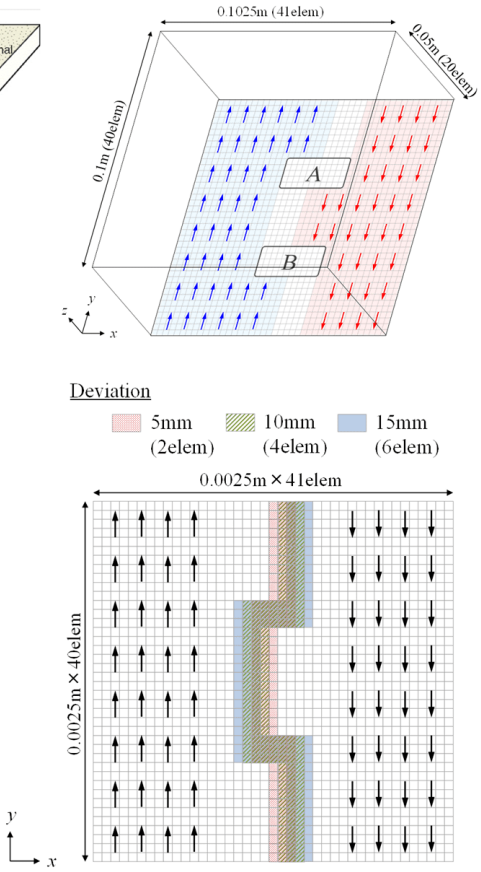

Fig. 3 Finite element mesh and boundary conditions

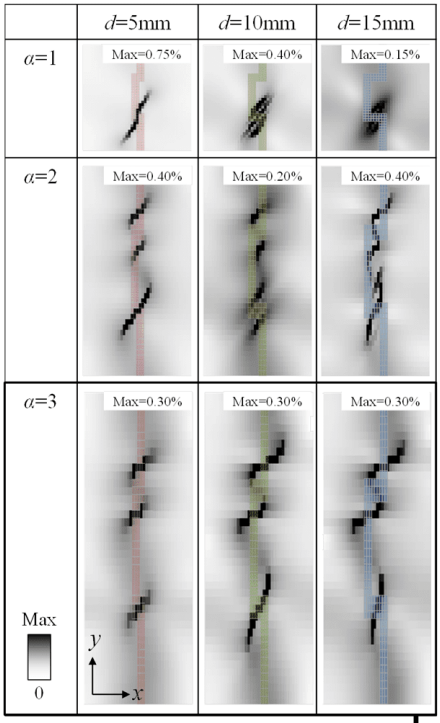

Fig. 4 Shear strain distributions at the surface

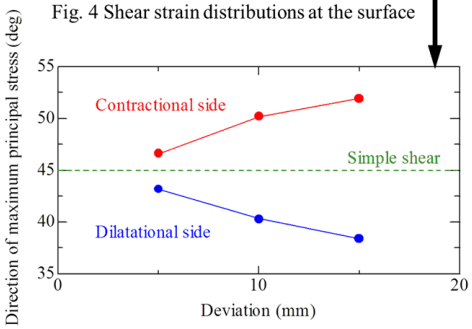

Fig. 5 rotation of the direction of principle stress

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A survey on earthquake prediction and public warning in seismological community

*Yoshinari Hayashi[1]

1. Faculty of Societal Safety Sciences, Kansai University

We conducted a questionnaire survey to clarify the comprehensive understanding of earthquake researchers about pre-earthquake prediction information. We divided the process up to the earthquake prediction information in following four stages, (1) the presence or absence of a phenomenon preceding a big earthquake, (2) the observability of the phenomenon, (3) the possibility of judging the observed data as abnormal, (4) possibility of public announcement of predicted earthquake information. We asked each researcher to respond with a numerical value of 10% from 0% to 100%. In addition, we asked for the probability of the success rate that the earthquake will occur in several days to one week.

A total of 129 researchers covered the delegates of the Japan Seismology Society, and 90 % respondents got responses. As delegates from the seismological society are elected by election by members, it can be thought that researchers who have certain insight in the field are selected. Responding to the questionnaire was basically based on requesting face-to-face at the meeting of the Fall Meeting in 2018, and asked for a reply by e-mail to those who could not do so.

In the tentative counting result, there is a wide range of responses from 0% to 100% in any of the four stages until public announcement success of the earthquake prediction information, and among seismologists it is obvious that there are various recognition in earthquake prediction. The average value of each stage is (1) "presence / absence of phenomenon" 47%, (2) "availability of observation" 47%, (3) "judgeability of the observed data as abnormal " 28%, (4) " public announcement possibility of predicted information" 41%. When we multiplied all respondents' answers of all four stages, the average value was only 6%. This is lower than the value expected by citizens and administration. In order to master information with low probability and low announcement frequency, it is necessary to consider reasonable countermeasures on the premise of a longer warning period with extremely low prediction rate and hit rate in comparison with civic perception.

Keywords: earthquake prediction, Nansai trough earthquake, Survey

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Long-period strong ground motion of the Tokyo Bay area during the events occurred in the plate triple junction area

*Tomiichi Uetake[1]

1. R&D Department, TEPCO research Institute, Tokyo Electric Power Company

Uetake (2018) analyzed the velocity records of the Tokyo Bay area during the M6.7 earthquake of September 23, 2016 occurred in the north side of the plate triple junction. The velocity spectra of these data showed that the short period component was small and the component with the period of 10 seconds was large comparing with the records observed during the same magnitude events and at almost same distance. After that, in the south side of the triple junction area, two M5.9 earthquakes occurred on December 24, 2018, and one M5.7 earthquake occurred on December 25, so we have compared these earthquake records with those of the 2016 event. Furthermore, we tried to compare to the records of the north side events along the Japan Trench.

First, we analyzed the characteristics of the records from the M5.9 earthquake occurred at 9:18 on December 24, 2018. We used the records obtained by the broadband velocity type strong-motion seismograph installed in the thermal power plants on the Tokyo Bay shore. Four observation stations exist on the east coast of the Tokyo Bay and eight observation stations exist on the west coast. The epicentral distance is from 210 to 230 km for the observation points on the east coast and Yokosuka. The epicentral distance is from 230 to 240 km for the observation points on the west coast except for Yokosuka. Long-period ground motion continued for a long time in the velocity traces at any observation point, and the significant wave packets are recognized especially at observation stations in the northeastern coast of Tokyo Bay. The velocity response spectrum with damping of 5% were calculated from observed data, there is a peak at around 10 seconds in period at any observation station, and the short period side is small. The amplitude of the spectra at period of 1 to 2 seconds is under one-fifth of amplitude at period of 10 seconds. A clear group dispersion was recognized in the waveform of the northeastern coast of the Tokyo bay by the multi-pass filter analysis, this means that the surface wave component was dominant. These features are similar to the M6.7 event in 2016. A similar tendency can also be confirmed with the M 5.9 event at 9:43 on December 24, 2018 and the M5.7 event on 25 December 2019.

Next, we compared the ground motions of the 2018 events with those of the events occurred in the north side of the plate triple junction along the Japan Trench. The events with M 5.7 or more occurred in the south area from 35.5 degrees north latitude in 2008 to 2018 were selected. There are few occurrences of large earthquakes in this area, and the next 4 events were selected. M 5.5 on May 2, 2013, M 6.1 on March 12, 2011, M 6.0 on April 14, 2011 and M 5.9 on 23 December 2013 in order from the south. Examining the characteristics of the velocity response spectrum with damping of 5% of these events, the velocity response spectra of the event on May 2, 2013 shows a similar shape to the events in the vicinity of the triple junction, but those of the other three events show different shape. The velocity response spectra of these three events are large in the short period side and almost the same amplitude in the period range from around 2 seconds to 10 seconds as shown in figure. This suggests that there is a regionality in the seismic source characteristics of the earthquake along the Japan Trench.

Keywords: Long-period strong ground motion, Surface waves, Source characteristics

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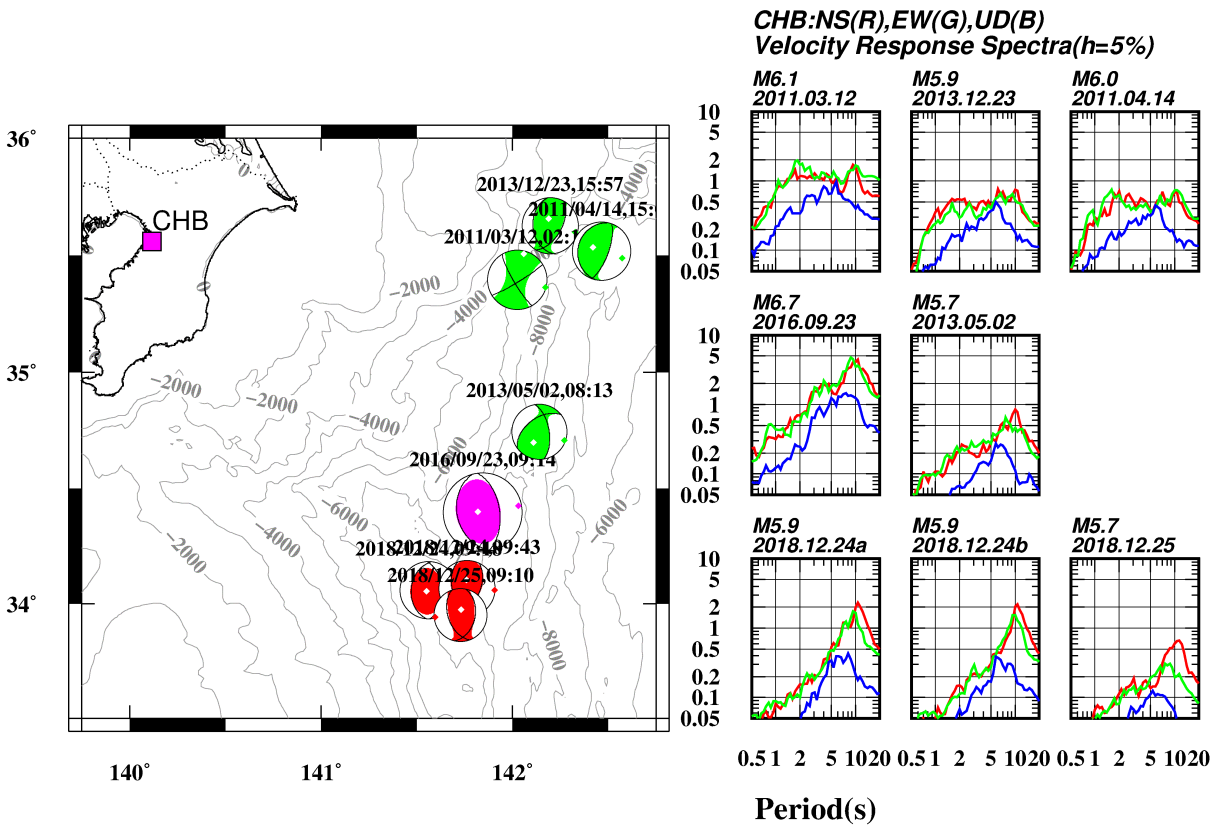

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Time-frequency and engineering characteristics on offshore ground motion

*CHEN Su[1], FU Lei[1], LI Xiaojun[1]

1. Institute of Geophysics, China Earthquake Administration

Based on the offshore ground motions collected from California, U.S and Sagami trough zone, Japan, the time-frequency distribution feature of offshore ground motions was analyzed by Hilbert-Huang transform method. The corresponding spectral accelerations and dynamic amplification factor spectrum were compared with the design spectra in relevant seismic design standards. The research results indicate that, the offshore ground motions contain a wealth of long period component, the long period and ultra-long period component were dominant in frequency range. The energy distribution of the normalized marginal spectrum was correlated with epicenter distance. The horizontal offshore ground motion’ s energy was much larger than that of the vertical ground motion. Moreover, the further finds show that the dynamic amplification factor β-values of most offshore ground motions are greater than the current platform value of seismic design standards used, i.e., their long-period components are comment larger than that the seismic design standards given, so it is risky to carry out offshore facilities seismic design by land seismic design standards. In view of that there are lots of actual engineering structure, such as long-span bridges, oil and gas platform, etc., the long period components of offshore ground motions should be paid more attention in offshore engineering structure seismic design.

Keywords: Offshore ground motion, Seismic design, Hilbert-Huang transform method

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Long-period Ground Motion from Hypothetical Megathrust Earthquakes along the Nankai Through using the Ambient Seismic Field

*Loic Viens[1], Tomotaka Iwata[1]

1. Disaster Prevention Research Institute, Kyoto University

Long-period ground motions from megathrust earthquakes are a real threat for large-scale human-made structures. The Nankai subduction zone, Japan, is expected to host a major megathrust earthquake in the near future and has therefore been instrumented with offshore and onshore permanent seismic networks. To simulate the long-period ground motions that could be generated by such earthquakes, we take advantage of the continuous data recorded offshore (DONET1 and DONET2 seismic stations) and onshore (Hi-net stations). We compute offshore-onshore impulse response functions from the continuous records using seismic interferometry by deconvolution. After amplitude calibration, we show that the impulse response functions reproduce well the long-period ground motions of moderate (M_w ~5) earthquakes. We construct realistic source models of several M_w 8+ earthquake scenarios that we use together with the computed impulse response functions to predict the long-period ground motions in the surrounding region. We finally calculate the velocity spectral response of our simulated waveforms and compare them to those obtained with ground motion prediction equations. This study suggests that the ambient seismic field recorded by the ever-increasing number of ocean bottom seismometers can be used to simulate the long-period ground motions from megathrust earthquakes.

Keywords: Long-period ground motion, Seismic noise, Green's function

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Fault model and strong ground motion evaluation for the Nankai megathrust earthquake

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1. Ohsaki Research Institute, Inc., 2. National Research Institute for Earth Science and Disaster Resilience

In this study, based on the estimated seismic source area and tsunami source area for the Nankai megathrust earthquake by the Cabinet Office (2012), we figured out the fault parameters for the seismic source, by the procedure of Ju *et al.* (2016) for the subduction plate-boundary earthquakes whose ruptures reach the ground surface (sea bottom). Then, we evaluated the strong ground motions at 10 locations in and around Aichi prefecture and Osaka prefecture, using the empirical Green's function method. As the results of the Nankai megathrust earthquake model, the velocity response spectra of ground motion results of NGY station were about 250cm/s at the peak period 3s, and those of OSK005 were about 100cm/s to 200cm at the period 3s to 4s.

Keywords: Subduction plate-boundary earthquakes, Surface fault breaking, Strong ground motion evaluation, Nankai megathrust earthquake, Asperity model, Empirical Green’s function method

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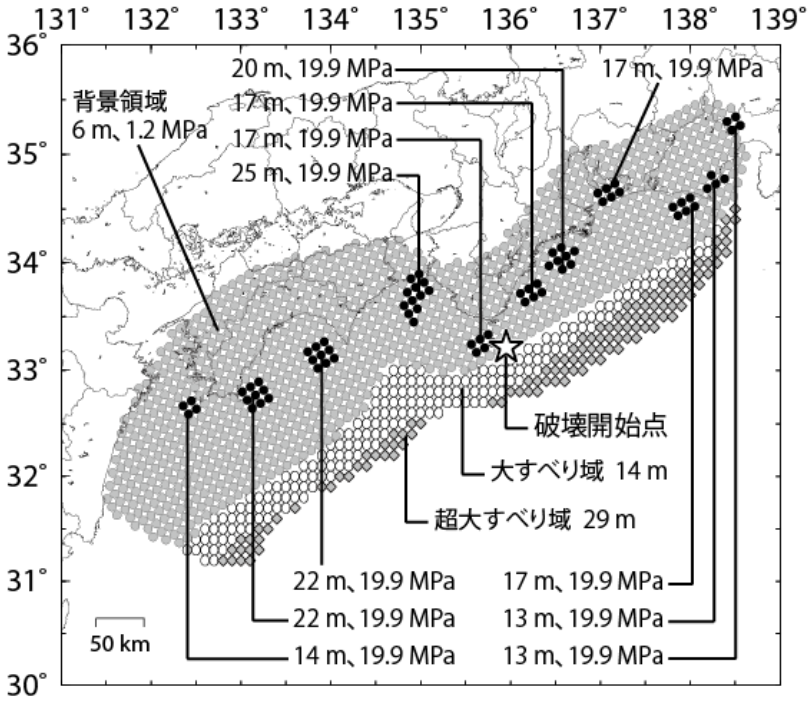


図 1　南海トラフ巨大地震の断層モデル

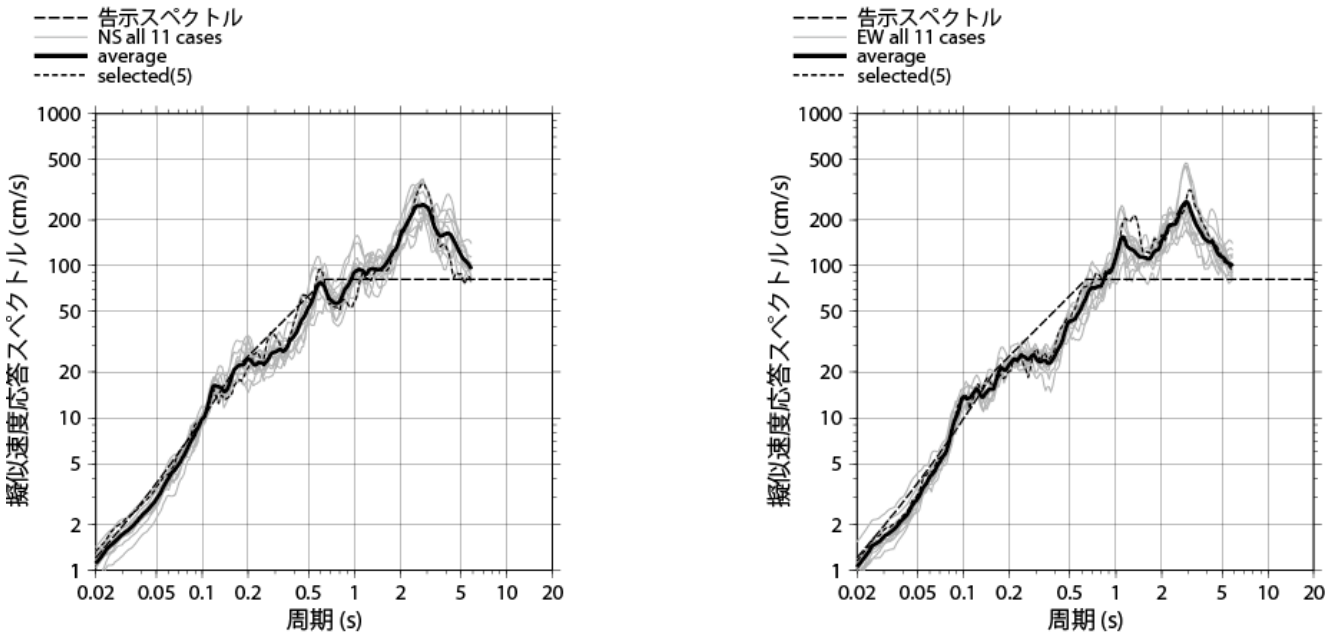
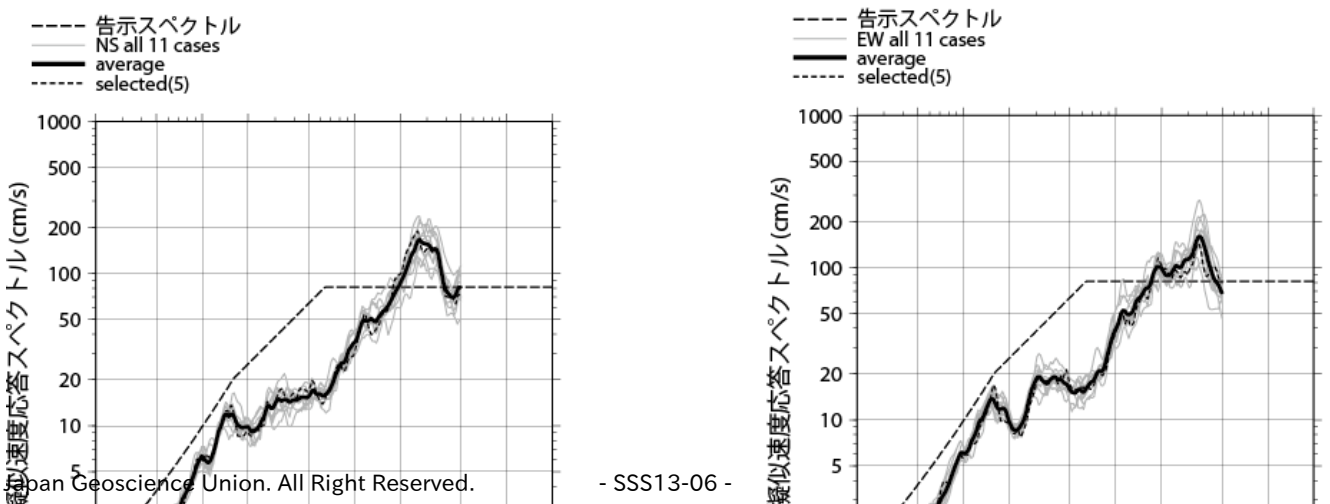


図 2　名古屋の三の丸 (NGY 観測点) における地震動評価結果（減衰定数 5%）



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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Susumu Kurahashi(Aichi Institute of Technology), Masahiro Korenaga(Railway Technical Research Institute)

Strong ground motion has social impacts as it induces earthquake disasters. We solicit contribution on any seismological topics related to strong ground motion that includes, but are not limited to, source processes, wave propagation, and site effects. We also welcome contribution on earthquake related disaster mitigation.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS13-07] One cause of the strong ground motion characteristics in Mukawa town during the 2018 Hokkaido eastern Iburi earthquake

*Nobuo TAKAI[1], Michiko Shigefuji[2], Takahiro Maeda[3], Masayoshi Ichiyanagi[1], Hiroaki Takahashi[1] (1.Hokkaido University, 2.Kyushu University, 3.NIED)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS13-08] Estimation of SMGA source model during the 2018 Hokkaido Eastern Iburi (Mw6.6) earthquake

*Susumu Kurahashi[1], Kojiro Irikura[1] (1.Aichi Institute of Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS13-09] Strong ground motion prediction for the source fault model of Futagawa and Hinagu active fault zones (1) -Construction of the basin velocity structure model-

*Kimiyuki Asano[1], Tomotaka Iwata[1], Masayuki Yoshimi[2], Hiroe Miyake[3], Haruko Sekiguchi[1], Shinichi Matsushima[1], Hiroshi Kawase[1], Fumiaki Nagashima[1], Hiroaki Yamanaka[4], Kosuke Chimoto[4], Nobuyuki Yamada[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Shigeki Senna[7], Takahiro Maeda[7], Atsushi Wakai[7], Asako Iwaki[7], Kaoru Jin[9], Hidetaka Saomoto[2], Seiji Tsuno[8], Masahiro Korenaga[8], Takeshi Sugiyama, Haruhiko Suzuki[9], Hisanori Matsuyama[9], Shunpei Manabe[9], Atsushi Yatagai[9], Shigeru Okamoto[10], Masaki Suehiro[10] (1.Disaster Prevention Research Institute, Kyoto University, 2.Geological Survey of Japan, AIST, 3.University of Tokyo, 4.Tokyo Institute of Technology, 5.Kochi University, 6.Kyushu University, 7.National Research Institute for Earth Science and Disaster Resilience, 8.Railway Technical Research Institute, 9.OYO Corporation, 10.Hanshin Consultants Co., Ltd.)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS13-10] Strong ground motion prediction for the source fault model of Futagawa and Hinagu active fault zones (2)-Strong ground motion prediction -

*Tomotaka Iwata[1], Kimiyuki Asano[1], Masayuki Yoshimi[2], Hiroe Miyake[3], Haruko Sekiguchi[1], Shinichi Matsushima[1], Hiroshi Kawase[1], Fumiaki Nagashima[1], Hiroaki Yamanaka[4], Kosuke Chimoto[4], Nobuyuki Yamada[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Shigeki Senna[7], Takahiro Maeda[7], Asako Iwaki[7], Kaoru Jin[7], Hidetaka Saomoto[2], Seiji Tsuno[8], Masahiro Korenaga[8], Syunpei Manabe[9], Haruhiko Suzuki[9], Hisanori Matsuyama[9], Yatagai Atsushi[9] (1.Disaster Prevention Research Institute, Kyoto University, 2.Geological Survey of Japan, AIST, 3.University of Tokyo, 4.Tokyo Institute of Technology, 5.Kochi University, 6.Kyushu University, 7.National Research Institute for Earth Science and Disaster Resilience, 8.Railway Technical Research Institute, 9.OYO Corporation)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS13-11] Near-surface geophysical survey and hearing survey of housing damages at Yasunaga district, Mashiki Town stricken by the 2016 Kumamoto Earthquakes

*Tomio INAZAKI[1], Takanori Ogahara[1], Hiroshi Kisanuki[2] (1.Public Works Research Institute, Tsukuba Central Institute, 2.PWRI (Present Address: OYO Corporation))

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SSS13-12] Evaluation on Influence of Shallow Subsurface Structures to Earthquake Ground Motions in the Kumamoto Plain, Using the Borehole Seismic Data

*Masahiro Korenaga[1], Seiji Tsuno[1], Hiroaki Yamanaka[2], Kosuke Chimoto[2] (1.Railway Technical Research Institute, 2.Tokyo Institute of Technology)

One cause of the strong ground motion characteristics in Mukawa town during the 2018 Hokkaido eastern Iburi earthquake

*Nobuo TAKAI[1], Michiko Shigefuji[2], Takahiro Maeda[3], Masayoshi Ichiyanagi[1], Hiroaki Takahashi[1]

1. Hokkaido University, 2. Kyushu University, 3. NIED

The Hidaka mountain range, central Hokkaido, Japan, formed by the Hidaka arc-arc collision zone, with the Ishikari eastern fault zone on the west side and the Tokachi plain fault zone on the east side. The 2018 Hokkaido eastern Iburi earthquake (Mw 6.6) occurred on September 6, 03:08 JST at this arc-arc collision zone. The Japan Meteorological Agency (JMA) magnitude (Mj) was 6.7 and hypocentral depth was 37 km. The maximum seismic intensity (JMA-scale) 7 was observed in Atsuma town. During this earthquake, 41 people died mainly by a widespread large landslide in Atsuma town. The many building damages by strong ground motion were concentrated around HKD126 site. At K-NET HKD126 and JMA Atsuma Shikanuma stations, strong motion records had strong power to destroy the timber frame buildings. It is an important examination to know the cause of the generation of this destructive strong motion in spite of a low magnitude and deep focus.

We have conducted observations (2018 September 10- December 16) of earthquake ground motion due to aftershocks of this earthquake at near hillside station (MKW01). The target stations' underground shear wave velocity structures were estimated by microtremor array observation and multichannel analysis of surface waves method (Shigefuji et al 2019 Jpgu). We calculated theoretical amplification factor of the SH wave with the estimated shear wave velocity structure. The amplification factor of HKD126 is 5 times larger than the one of the MKW01 at a frequency around 1 Hz. Cause of this tendency are affected by low shear wave velocity in shallow part in HKD126; the engineering bedrock of HKD126 is deeper than the MKW01. We carried out the strong ground motion high-density line array observation (2018 December 01-16) along the line of HKD126 to MKW01 in Mukawa town, to know the changing of the ground motion amplitude by underground structures. We choose the earthquake records which were not affected by the nonlinear effect of soft soil. In these observed spectra, we can also understand the different amplitude as same as the theoretical ones. However, the predominant periods during mainshock is longer than this predominant period of theoretical and weak motion records. Generally, the strong ground motions are affected by the nonlinear response of surface soft soil. The strong motion record of HKD126 was examined the nonlinear effects by the DNL (degree of nonlinear effect) methods. The DNL value is 14.7; this value means large nonlinearity occurred (Noguchi et al. 2013) and the predominant period of the 1-2 s might be moved from the short-period side by this large nonlinearity. The strong ground motion power of 1-2 s during the main shock at HKD126 site was mainly amplified by this shallow underground velocity structure and this predominant range was conceivable changed for long periods side with nonlinear effect moreover.

A further step for studying this earthquake, we will examine the nonlinear effect for HKD126 in detail and we will spread the target area to examine the strong ground motion spatial distribution and discuss the 3-D underground structure.

A part of this study was supported by the Grant-in-Aid for Scientific Research No. 18K19952 and 17H06215 from MEXT of Japan, and MEXT of Japan’ s Earthquake and Volcano Hazards Observation and Research Program.

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Keywords: the 2018 Hokkaido eastern Iburi earthquake, Shear wave velocity, Site amplification

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Estimation of SMGA source model during the 2018 Hokkaido Eastern Iburi (Mw6.6) earthquake

*Susumu Kurahashi[1], Kojiro Irikura[1]

1. Aichi Institute of Technology

1. Introduction

The 2018 Hokkaido Eastern Iburi earthquake (Mw6.6, depth: 37km) occurred in the western Iburi region of Hokkaido, Japan, on September 6, 2018. The maximum seismic intensity with 7 was observed at Atsuma-cho. PGA of 1796 gal is observed at the HKD127(Oiwake) staion. Strong motions during this earthquake were widely observed, because the source depth was deep. We estimated the SMGA source model by comparing the synthetic and observed ground motions from the 2018 Hokkaido Eastern Iburi earthquake.
The observed records of this earthquake have some specific features. The observed ground motion at HKD126 station located in south of hypocenter has pulse-wave with maximum velocity of 158 cm/s. The observed record at HKD127 station located in north of hypocenter has three wave-packets. Observed ground motions at other stations also show three-wacepackets. Then, we estimated the SMGA source model considering these features seen in the observed records.

2. Estimation of the SMGA source model using empirical Green's function method

We constructed a characterized source model with SMGAs based on the slip distribution model inverted by Japan Meteorological Agency (2018). The source model of JMA. (2018) consists of one segment fault plane.
The EGF events whose records are used as the EGFs are selected to have hypocenters close to the SMGAs with almost the same radiation characteristics as the target events. We selected the records of an aftershock (Mw 4.3) as the empirical Green's functions based on the above conditions.
We calculated the spectral ratios between the mainshock and the EGF events to estimate the corner frequency of the EGF events. The source area and stress parameter of the event were estimated as 3.3km2 and 1.5MPa, respectively, from the seismic moment and the corner frequency using Brune's (1970, 1971) formula.
A SMGA area is divided into N x N subfaults, the area of which is taken to be equal to the fault area of each EGF event. Target frequency range is 0.5 - 10Hz. The best-fit characterized source model to simulate ground motions from the mainshock using the EGF method was determined, choosing the starting point, rupture velocity, and slip duration by comparing the observed and synthetic waveforms. The criterion of the best-fit model is to minimize the residuals between the observed and synthetic waveforms. The residual is defined as the sum of the squared residuals of displacement waveforms and acceleration envelopes at KiK-net stations. On the other hands, at K-NET stations, the residual is defined as the sum of the squared residuals of displacement and velocity waveforms to avoid non-lenear site effects on acceleration motions.
The best fitting SMGA source model has three SMGAs. The locations of the SMGAs are the northerm part, southern part and shallow part of the hypocenter. The areas and stress parameters of the SMGAs were estimated to be 136 km^2 and 20-25MPa, respectively. The area of combined SMGAs is agreement in comparison with the scaling relationship of combined asperity area versus seismic moment from Irikura and Miyake (2001).

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We are analyzing the detailed SMGA source model assuming with multi-segments with defferent strike and dip for each SMGA.

Keywords: the 2018 Hokkaido Eastern Iburi earthquake, strong motion generation area

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Strong ground motion prediction for the source fault model of Futagawa and Hinagu active fault zones (1) -Construction of the basin velocity structure model-

*Kimiyuki Asano[1], Tomotaka Iwata[1], Masayuki Yoshimi[2], Hiroe Miyake[3], Haruko Sekiguchi[1], Shinichi Matsushima[1], Hiroshi Kawase[1], Fumiaki Nagashima[1], Hiroaki Yamanaka[4], Kosuke Chimoto[4], Nobuyuki Yamada[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Shigeki Senna[7], Takahiro Maeda[7], Atsushi Wakai[7], Asako Iwaki[7], Kaoru Jin[9], Hidetaka Saomoto[2], Seiji Tsuno[8], Masahiro Korenaga[8], Takeshi Sugiyama, Haruhiko Suzuki[9], Hisanori Matsuyama[9], Shunpei Manabe[9], Atsushi Yatagai[9], Shigeru Okamoto[10], Masaki Suehiro[10]

1. Disaster Prevention Research Institute, Kyoto University, 2. Geological Survey of Japan, AIST, 3. University of Tokyo, 4. Tokyo Institute of Technology, 5. Kochi University, 6. Kyushu University, 7. National Research Institute for Earth Science and Disaster Resilience, 8. Railway Technical Research Institute, 9. OYO Corporation, 10. Hanshin Consultants Co., Ltd.

The sub-theme #3 of the Comprehensive Research Project for the Major Active Faults Related to the 2016 Kumamoto Earthquake by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) developed a three-dimensional underground seismic velocity structure model in the Yatsushiro plain and other areas for improving strong motion prediction for future earthquakes along the Futagawa and Hinagu fault zones because there are still un-ruptured segments remained on these two fault zones.
In the Yatsushiro plain, which is located along the Hinagu fault, seismic reflection surveys using a P-wave vibrator were conducted along two lines in 2017 (Uki line and Yatsushiro line) to investigate the underground structure down to the seismic bedrock. Temporary strong motions stations were installed at 37 sites covering the whole area of the Yatsushiro plain. Small-size microtremor array survey was also conducted at these temporary stations. Large-size microtremor array surveys were carried out at 29 sites with a maximum array radius of 500-600 m in the whole area of the plain. Miniature and irregular array microtremor observations were conducted to survey shallow subsurface structure at 32 sites in the southern part of the Yatsushiro plain. Single-station microtremor H/V observations were carried out at 31 sites in the boundary area between the Yatsushiro and the Kumamoto plains.
Microtremor array measurements were also conducted at most of strong motion stations in the Amakusa Islands, the Minamata-Ashikita area, the Hitoyoshi basin, the Izumi plain, the Tamana plain, the Kikuka basin, Aso area, and the southern part of the Shimabara peninsula, which consists of 23 Large-size arrays and 76 small-size arrays. Single-station microtremor H/V observations were conducted at 47 sites in the Izumi plain and 44 sites the Tamana plain to investigate the spatial variation in the bedrock depth. Miniature and irregular array microtremor observations were also conducted at 48 sites in the Hitoyoshi basin. Hot-springs boring well-logs were collected in the Yatsushiro plain, the Mianamata-Ashikita area and the Hitoyoshi basin.
We modeled the 3D velocity structure above the seismic bedrock using these survey data and existing information. For the Yatsushiro plain, the Rayleigh wave phase velocity and H/V spectra from the microtremor observations were jointly analyzed to obtain the S-wave velocity profile at each measurement site. When we analyzed microtremor data, we referred to seismic reflection profiles and boring log as constraint information for bedrock depth. The sedimentary layers were modeled by two layers with S-wave velocities of 0.6 and 0.9 km/s. Shallow low-velocity layers were also considered above the layer of 0.6 km/s, and we assumed a layer of Vs 2.7 km/s at the top of the seismic bedrock (Vs 3.1 km/s). The top depth of Vs 2.7 km/s is well correlated with the bedrock depth from the reflection surveys, and its depth

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ranges from 0.3 to 0.6 km. The thickness of Vs 0.9 km/s is relatively large along the Yatsushiro line compared to the Uki line, which is consistent with interval velocities along these survey lines. Initial velocity model was constructed by the results of microtremor array analysis, and it was revised with H/V spectra at sites where phase-velocity dispersion curve was not available after checking consistency with gravity anomaly and boring well data.
Deep sedimentary velocity structure models were also constructed in the Hitoyoshi basin, the Amakusa Islands, Izumi plain and others using microtremor array surveys. The sedimentary layers were modeled by three layers with Vs 0.6, 0.9 and 1.6 km/s. Hot-spring borehole logs were also used in the Hitoyoshi basin. The seismic bedrock depth (Vs 3.1 km/s) is relatively deep in the eastern part of the Hitoyoshi basin (1.0~1.5 km). The top depth of Vs 1.6 km/s is relatively shallow around Amakusa Kamishima Island, which is consistent with high Bouguer anomaly in this area. The bedrock in the Izumi plain deepens toward the coast.
The final product of the 3D deep sedimentary velocity structure model and its validation by ground motion simulations will be presented in this presentation.

Acknowledgements: This work was conducted as a part of the Comprehensive Research Project for the Major Active Faults Related to the 2016 Kumamoto Earthquake of MEXT. The undergraduate and graduate students from Kyushu University, Tokyo Institute of Technology and Kyoto University participated in the field observations. We also sincerely appreciate local governments and residents in the area for helping our field works.

Keywords: deep sedimentary velocity structure model, strong motion prediction, Hinagu fault zone, Futagawa fault zone

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Strong ground motion prediction for the source fault model of Futagawa and Hinagu active fault zones (2) -Strong ground motion prediction -

*Tomotaka Iwata[1], Kimiyuki Asano[1], Masayuki Yoshimi[2], Hiroe Miyake[3], Haruko Sekiguchi[1], Shinichi Matsushima[1], Hiroshi Kawase[1], Fumiaki Nagashima[1], Hiroaki Yamanaka[4], Kosuke Chimoto[4], Nobuyuki Yamada[5], Tatsuo Kanno[6], Michiko Shigefuji[6], Shigeki Senna[7], Takahiro Maeda[7], Asako Iwaki[7], Kaoru Jin[7], Hidetaka Saomoto[2], Seiji Tsuno[8], Masahiro Korenaga[8], Syunpei Manabe[9], Haruhiko Suzuki[9], Hisanori Matsuyama[9], Yatagai Atsushi[9]

1. Disaster Prevention Research Institute, Kyoto University, 2. Geological Survey of Japan, AIST, 3. University of Tokyo, 4. Tokyo Institute of Technology, 5. Kochi University, 6. Kyushu University, 7. National Research Institute for Earth Science and Disaster Resilience, 8. Railway Technical Research Institute, 9. OYO Corporation

The research group for the Comprehensive Research Project for the Major Active Faults Related to the 2016 Kumamoto Earthquake supported by MEXT (PI: Prof. Hiroshi Shimizu, Kyushu Univ.) has conducted an integrated research on long-term evaluation of earthquake occurrence of active faults (Sub-theme 1), seismic activity and crustal structure (Sub-theme 2), strong ground motion prediction (Sub-theme 3) and outreach (Sub-theme 4). The research group of Sub-theme 3 developed a three-dimensional underground seismic velocity structure model in and around the source area and strong ground motion prediction for future earthquakes along the Futagawa fault zone and the Hinagu fault zone as there are still un-ruptured segments remained on these two fault zones after the 2016 Kumamoto earthquake. In this paper, we present the strong ground motion predictions.

Asano et al. (2019) explained how to develop the three-dimensional velocity structure model up to the engineering bedrock. We developed a subsurface velocity structure model down to the engineering bedrock, using boring database and miniature-size microtremor array measurement (e.g. Senna et al., 2018). We constructed source fault models for the Futagawa fault zone (Uto and Uto-hanto-hokugan segments) and for the Hinagu fault zone (Takano-Shirahata, Northern Hinagu, Southern Hinagu, Northern Yatsushiro Sea, and Southern Yatsushiro Sea segments). The location of the modeled source fault of the Uto segment is set to about 1km north from the present one (HERP, 2013). The active fault traces of the Hinagu fault segments are slightly modified from the research results by Sub-theme 1. We assumed two kinds of models for the dip angle setting of the source fault of the Southern Hinagu segment, 90deg. and 50deg. The latter is assumed referring to the microearthquake distribution by Sub-theme 2. The rake angle for each source fault was determined from the stress conditions of the source fault area by the stress inversion result (Sub-theme 2). The earthquake moment magnitude of the future Futagawa and Hinagu fault zones are 7.0 and 7.3-7.4, respectively.

We used “The Recipe” (Strong ground motion prediction for earthquakes with specified source model) (HERP, 2016) for strong ground motion prediction. The rupture starting points were assumed from the implication of the rupture starting point of the 2016 Kumamoto mainshock on the crustal resistivity distribution (Sub-theme 2). The hybrid (FDM and stochastic Green’s function method) method with the cross-over period of 1 sec was used for simulating ground motions on the engineering bedrock. Seismic equivalent linear analysis was applied to the area of the subsurface velocity model to get the time history of the ground motions at the surface and JMA seismic intensity was calculated using the simulated waveform data. Additionally, we estimated a JMA seismic intensity distribution in Kumamoto prefecture using PGV values of the engineering bedrock and JMA seismic intensity increments by the micro-topography classification and Vs30 values.

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Keywords: 2018 Kumamoto earthquake, Strong ground motion prediction, Futagawa fault zone, Hinagu fault zone

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Near-surface geophysical survey and hearing survey of housing damages at Yasunaga district, Mashiki Town stricken by the 2016 Kumamoto Earthquakes

*Tomio INAZAKI[1], Takanori Ogahara[1], Hiroshi Kisanuki[2]

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We conducted a detailed geophysical survey to the near surfaces and hearing survey of housing damages at Yasunaga District, Mashiki Town stricken by the 2016 Kumamoto Earthquakes. The geophysical survey was carried out in March 2017 along a 350 m long short survey line set on a road between Route 28 and Akitsu River. Hearing survey was also conducted along the survey line. We directly interviewed with residents in May 2018, or indirectly inspected housing sites. A total of 31 dwellings were surveyed supported by board members of the Yasunaga District community association. We could have quite valuable information on the earthquake related evidences as exemplified as follows; 1) ground water sprang out from an open crack under the floor and the housing was divided into two segments. 2) Dry wells revived just after the earthquake and were still pouring ground water. 3) Bulges were generated along a street or the boundaries between roads and dwellings. Different types were reported on the mode of occurrence of ground deformation between the northern and the southern part of the surveyed district. No specific deformed structure or faulting structure was identified in the near surfaces along the survey line set in the Yasunaga District. In contrast, a thick soft layer characterized as low resistivity and low Vs occupied the surfaces up to 20 m deep at the southern half of the line, or Akitsu lowland area. The above evidences strongly suggest that surface deformed structure observed in the Yasunaga District was originated by non-tectonic forces influenced by local artificial topography and the existence of the soft layer instead of active faulting. Our survey results also demonstrate the importance of high-resolution near-surface geophysical surveying and direct interviewing to the residents for the detailed undestanding of local earthquake disasters.

Keywords: 2016 Kumamoto Earthquakes, Mashiki Town, Yasunaga District, near surface geophysics, housing damage survey

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Evaluation on Influence of Shallow Subsurface Structures to Earthquake Ground Motions in the Kumamoto Plain, Using the Borehole Seismic Data

*Masahiro Korenaga[1], Seiji Tsuno[1], Hiroaki Yamanaka[2], Kosuke Chimoto[2]

1. Railway Technical Research Institute, 2. Tokyo Institute of Technology

The Kumamoto Plain, located in the Northern part of Kumamoto prefecture, Kyushu island, is consist of diluvial plateau in the west slope of Mt. Aso and alluvial lowland formed by Shirakawa and Midorikawa. It is suggested that the earthquake ground motions are amplified largely and intricately, due to the complex and soft soil sediments.

To investigate characteristics of earthquake ground motions in the Kumamoto Plain, we installed temporary seismic stations along the north-south line in Kumamoto Plain, immediately after the 2016 Kumamoto earthquake. We obtained seismic data of the main shock (Mj 7.3, occurred on 4/16 2016) at 2 sites near Mt. Hanaoka, in the northern edge of the Kumamoto Plain. We showed that the strong ground motions observed at the 2 sites during the main shock, were affected by the non-linearity and the polarization to direction of north-south.

To clarify the cause of these distinctive trends of the ground motions, we conducted detailed observations and surveys the site where the main shock was recorded. We installed seismometers simultaneously on the ground and on the engineering bedrock at a depths of 40m, with a sample rate of 1000 Hz. We calculated the Fourier spectral ratio of the seimic data on the ground to the data on the engineering bedrock. As a result, we confirmed that the characteristics of the NS and EW component of the spectral ratio are clearly different around 1-4 Hz. It is suggested that complex shallow subsurface structure affects the polarization to direction of north-south.

In addition, we performed P-S logging to understand shear wave velocity of the alluvial soils to the engineering bedrock at this site. We compared site amplification factors estimated from weak ground motion data to those calculated from P-S logging data and S-wave velocity structures estimated by array microtremor observations. Finally, we discussed the influence of shallow subsurface structure to the earthquake ground motions in complex and soft soil sediments.

Keywords: 2016 Kumamoto earthquake, borehole seismometer, shallow subsurface structures

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Kentaro Kasamatsu(Kajima Corporation), Kazuhito Hikima(Tokyo Electric Power Company Holdings, Inc.)

Strong ground motion has social impacts as it induces earthquake disasters. We solicit contribution on any seismological topics related to strong ground motion that includes, but are not limited to, source processes, wave propagation, and site effects. We also welcome contribution on earthquake related disaster mitigation.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS13-13] Factors of large amplitude ground motions excited by small to moderate earthquakes
- Examination of KiK-net Kuriyama-nishi of the 2013 Tochigi-ken Hokubu Earthquake (Mj6.3) -

*Kentaro Kasamatsu[1], Kenichi Kato[2], Tetsushi Watanabe[2], Tetsuo Shiota[3] (1.Kajima Corporation, 2.Kobori Research complex inc., 3.Shikoku Electric Power CO.,Inc.)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS13-14] Source modeling and strong ground motion simulation in the Tokyo metropolitan area of the 1923 Kanto earthquake based on seismic intensity inversion analysis

*Fumino Suzuki[1], Kenichi Kato[1], Katsuhisa Kanda[1], Takashi Ikeda[1] (1.KOBORI RESEARCH COMPLEX INC.)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS13-15] A Simple Fault Model to Calculate Strong Ground Motions Including Fling Steps for the Main Shock of the 2016 Kumamoto Earthquake

*Atsushi Nozu[1], Yosuke Nagasaka[1], Shuanglan Wu[1] (1.Port and Airport Research Institute)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS13-16] **Fling-steps displacements by the discrete wavenumber method**

*SHUANGLAN WU[1], Atsushi Nozu[1], Yosuke Nagasaka[1] (1.PORT AND AIRPORT RESEARCH INSTITUTE)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS13-17] Extension of characterized source model for long-period strong motions near surface-rupture-earthquakes

*Kojiro Irikura[1], Susumu Kurahashi[1], Yasuhiro Matsumoto[2] (1.Aichi Institute of Technology, 2.KOZO_KEIKAKU Engineering, Inc.)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SSS13-18] A Study for the cause of earthquake damages by the 2014 Nakagano-ken Hokubu earthquake (M_J6.7) – consideration using the strong motion simulation –

*Kazuhito Hikima[1], Ryoichi Nakamura[2], Tomiichi Uetake[1] (1.Tokyo Electric Power Company Holdings, Inc., 2.Earthquake Research Institute, Univ. of Tokyo)

Factors of large amplitude ground motions excited by small to moderate earthquakes
- Examination of KiK-net Kuriyama-nishi of the 2013 Tochigi-ken Hokubu Earthquake (Mj6.3) -

*Kentaro Kasamatsu[1], Kenichi Kato[2], Tetsushi Watanabe[2], Tetsuo Shiota[3]

1. Kajima Corporation, 2. Kobori Research complex inc., 3. Shikoku Electric Power CO.,Inc.

In KiK-net Kuriyama-nishi (TCGH07), a large amplitude ground motion with peak acceleration of about 1.2G was observed in the 2013 Tochigi-ken Hokubu Earthquake (Mj6.3). Both borehole and surface records are characterized as being predominant about 6Hz. Hikima (2015) divided small to moderated earthquakes into five group based on the focal region, and examined the difference in site amplifications of TCGH07 using spectral inversion method. Predominant frequency around 6Hz are limited characteristics found only in earthquakes that occurred in the west and vicinity of TCGH07. He guessed that the cause was the influence of site amplification factor and path characteristics.

In this study, in order to investigate the factor of large amplitude earthquake ground motion of TCGH07 from another point of view, we estimated attenuation relationship of the peak acceleration of 5-8Hz ground motion using observation records of small to moderate earthquakes, and evaluated the amplification factor of TCGH07. Futhermore, we investigated the spatial distribution of the residuals for the attenuation relationship in TCGH07, and compared with slip distribution of the main shock.

The attenuation relationship was estimated using borehole records of 17 KiK-net observatories around TCGH07 for inland crustal earthquakes that occurred in the focal region of the main shock. The database used for this study consists of the 1147 records of 178 earthquakes in the range of the hypocentral distance about 3 to 100 km, the focal depth within about 11 km and Mj 2 to 5.2. Maximum acceleration amplitude of the larger of the two horizontal components was used. The attenuation relationship was estimated in a model obtained by adding the term of the site amplification factors to the regression model by Si and Midorikawa (1999). The coefficients for the hypocentral distance representing the viscous damping were given 0.002 with reference to Si and Midorikawa (1999). For the constraint of the solution, KiK-net Fujiwara-2 (TCGH17) with the highest S-wave velocity was taken as the reference of the site amplification factors.

Fig.(a) shows the site amplification factor evaluated at each observatory as the distribution for the S-wave velocity of the observation depth. It tends to be proportional to the reciprocal of S-wave velocity. If the relationship between them is approximated by a linear equation, the amplification factor evaluated in TCGH07 greatly exceeds this average relation. It can be said that TCGH07 is easy to shake at frequency 5-8Hz compared with surrounding observatories. The residual of the maximum acceleration amplitude (observation / attenuation relationship) was evaluated for each earthquake in TCGH07. Fig.(b) shows their spatial distribution. In this figure, the center of the color contour is adjusted to be the average value of the residuals. The gray contour denotes the slip distribution of the main shock by the Hikima (2014). Regional characteristics are found in the distribution of residuals, such as small in the earthquakes that occurred in the south and east, and large in the earthquakes that occurred in the west. Regions where the residuals are large roughly correspond to the slip region of the main shock. Fig.(c) shows the dependence of the residual on the back azimuth. Although there was a bias in the number of earthquakes, the average and

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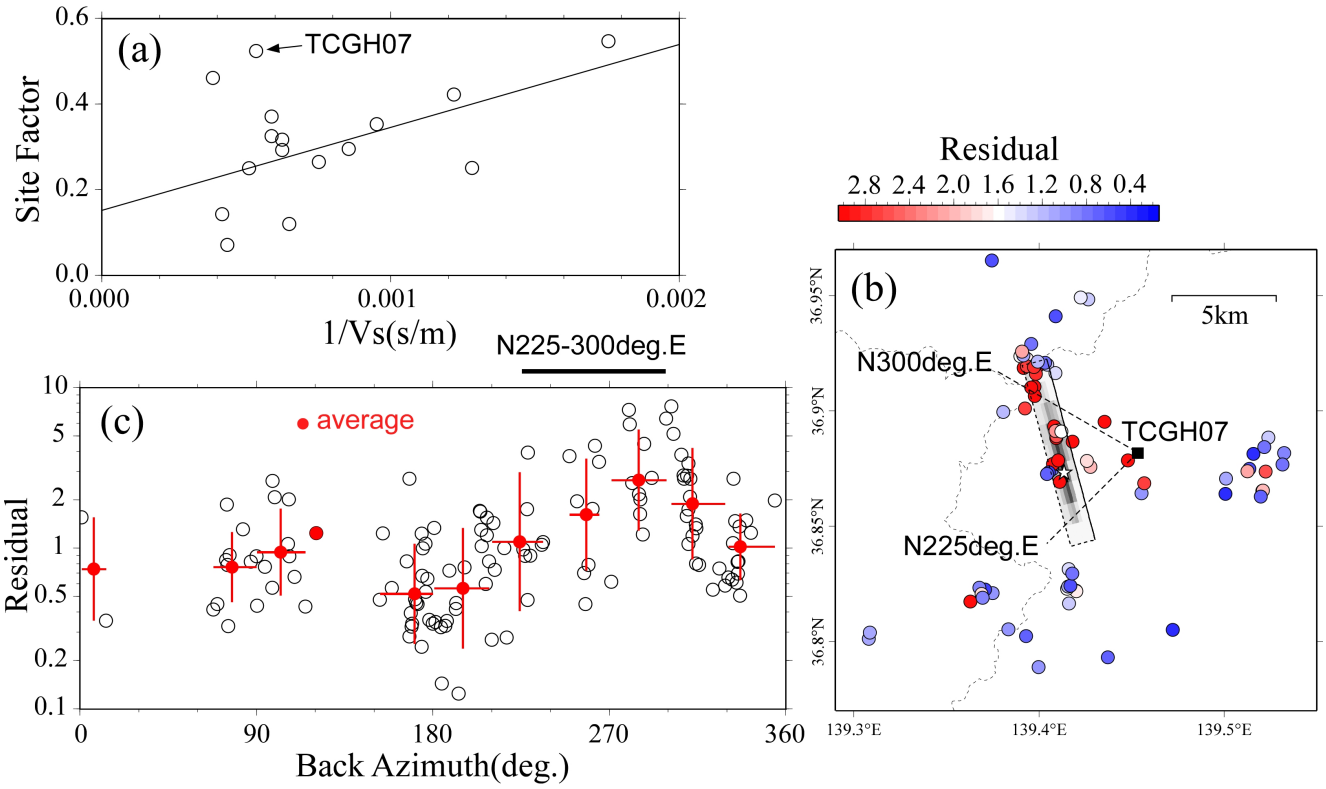
standard deviation calculated by grouping at 30 degree intervals were shown in red circles and lines respectively. Obvious orientation dependence was found. The residual is large in the case of the earthquake occurring in the direction of N225-300deg.E corresponding to the slip region of the main shock. In addition to the shakeability of TCGH07 around 6Hz, the amplitude of the earthquake ground motion is further increased in the case of the earthquake occurred around the slip region of the main shock.

At the time of the main shock, as one of the reasons why the large amplitude ground motion was observed in TCGH07, it can be considered that the site amplification factor is large around 6Hz as pointed by Hikima (2015). However, the regional characteristics of the residuals of the small to moderate earthquakes shown in this study may indicate differences in the excitation characteristics of earthquakes. In that case, even at the time of the main shock, short-period ground motion strongly excited in the region where the residuals were large further increased the amplitude of TCGH07. We are investigating the stress drop of small to moderate earthquakes that occurred in the focal region of main shock.

Keywords: 2013 Tochigi-ken Hokubu Earthquake, KiK-net Kuriyama-nishi, Large Amplitude, Attenuation Relationship



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Source modeling and strong ground motion simulation in the Tokyo metropolitan area of the 1923 Kanto earthquake based on seismic intensity inversion analysis

*Fumino Suzuki[1], Kenichi Kato[1], Katsuhisa Kanda[1], Takashi Ikeda[1]

1. KOBORI RESEARCH COMPLEX INC.

1. Introduction

The 1923 Kanto earthquake had serious damage to the Tokyo metropolitan area. It is concerned that similar large earthquake will occur repeatedly in the future. So, it is important to evaluate characteristics of the source and strong ground motions of this event. The short-period strong ground motions were not recorded during this event. Therefore, the seismic intensity data are effective for the source modeling used to the short-period strong motion simulation. Kanda and Kato (2018) evaluated the short-period spectral level of the acceleration source spectrum A, and number of strong motion generation area (SMGA) by the inversion analysis using seismic intensity data investigated by Moroi and Takemura (2002). In this study, the short-period spectral level A_i of six SMGA by Kanda and Kato (2018) are evaluated, and the strong ground motions of two sites in the Tokyo metropolitan area are simulated using the stochastic Green's function method.

2. Seismic source modeling

A_i's are evaluated referring to A, seismic moment of each SMGA M_{0ai}, and area S_{ai} by Kanda and Kato (2018). Assuming that omega-square model, Brune's model (Brune, 1970, 1971) and circular crack model (Eshelby, 1957) are applicable to modeling of each SMGA, A_i is proportional to M_{0ai}/S_{ai}.

The whole fault A is 4.66×10^{19}Nm/s^2 by Kanda and Kato (2018), and each SMGA A_i is 1.4 to 2.2 $\times10^{19}$ Nm/s^2. The whole fault A by Kato et al. (2013) is 2.46×10^{19}Nm/s^2, and maximum A_i has the almost same level as this. Kato et al. (2013) constructed the source model based on the slip distribution evaluated by Sato et al. (2005) using seismic waveform and geodetic data of The 1923 Kanto earthquake. Therefore this model reflects relatively long period ground motion. This study’ s model based on seismic intensity reflects relatively short period ground motion. Note that the difference.

Each SMGA is converted into a rectangular model holding the area. Strike and dip angle are set along the subducting the Philippine Sea plate. Background area is not considered. Other parameters (density, S wave velocity, rupture velocity (Vr), fmax and radiation pattern coefficient) are the same as those of Kato et al. (2013). Rise time of each SMGA is set from the relationship of $\tau_i=0.5S_i^{1/2}/Vr$. Rupture starting point of the whole fault is set on the SMGA located in the western Kanagawa, and rupture type of each SMGA is multi-hypocenter. The Q value is $100f^{0.7}$ (f is frequency) with reference to Central Disaster Management Council (2004).

3. Strong ground motion simulation

In order to the effect of the source model based on seismic intensity inversion to strong motions in the Tokyo metropolitan area, the strong motions at Asakawa and Etchujima evaluated by the stochastic

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Green's function method. Soil structural models follow Kato et al. (2013).
The results of the strong motions evaluation are investigated about differences of 2 sites, contributions of each SMGA and differences from strong motions using the source model of Kato et al. (2013).

Keywords: the 1923 Kanto earthquake, seismic intensity, short-period spectral level, strong motion generation area, strong ground motion simulation

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A Simple Fault Model to Calculate Strong Ground Motions Including Fling Steps for the Main Shock of the 2016 Kumamoto Earthquake

*Atsushi Nozu[1], Yosuke Nagasaka[1], Shuanglan Wu[1]

1. Port and Airport Research Institute

A composite source model was developed to simulate strong ground motions during the main shock of the 2016 Kumamoto earthquakes which can consider both fling steps due to slips near the site and pulses from deeper asperities. The authors' intention was to develop a simple source model which can be easily handled by engineers. To this end, a simple geodetic fault model by the Geospatial Information Authority of Japan (GSI), comprising of three faults with uniform slip, was used as a starting point and parameters related to the temporal evolution of the slip were added. The added parameters included the rupture starting point, rupture propagation pattern, rupture velocity and rise time. The resultant model was used as a background region, which was combined with asperities to form a composite source model. The ground motions from the background region were calculated by the discrete wavenumber method (Bouchon, 1981). The ground motions from the asperities were calculated by what we call "the corrected empirical Green's function method" (Kowada et al., 1998; Nozu et al., 2009). The simulation results showed that the composite model can well reproduce near-source displacement and velocity waveforms including fling steps at KMMH16, KMM006, KMM005, Komori and Kawayo, although the model was relatively simple in a sense that the slip-velocity function and the rise time were uniform throughout the background region. A closer look at the results showed that the fling steps were slightly overestimated or underestimated depending on the site. It was obvious that if we had introduced more complicated slip models, the results would have been closer to the observations. However, from an engineering point of view, it was a meaningful result that such a simple source model could explain ground displacements with fling steps without significant discrepancy because, in a prediction problem, it is difficult to assign a detailed slip distribution. On the other hand, to represent pulses with approximate periods of 1 s, it was definitely necessary to consider asperities.

Keywords: crustal deformation, fling step, the 2016 Kumamoto earthquakes

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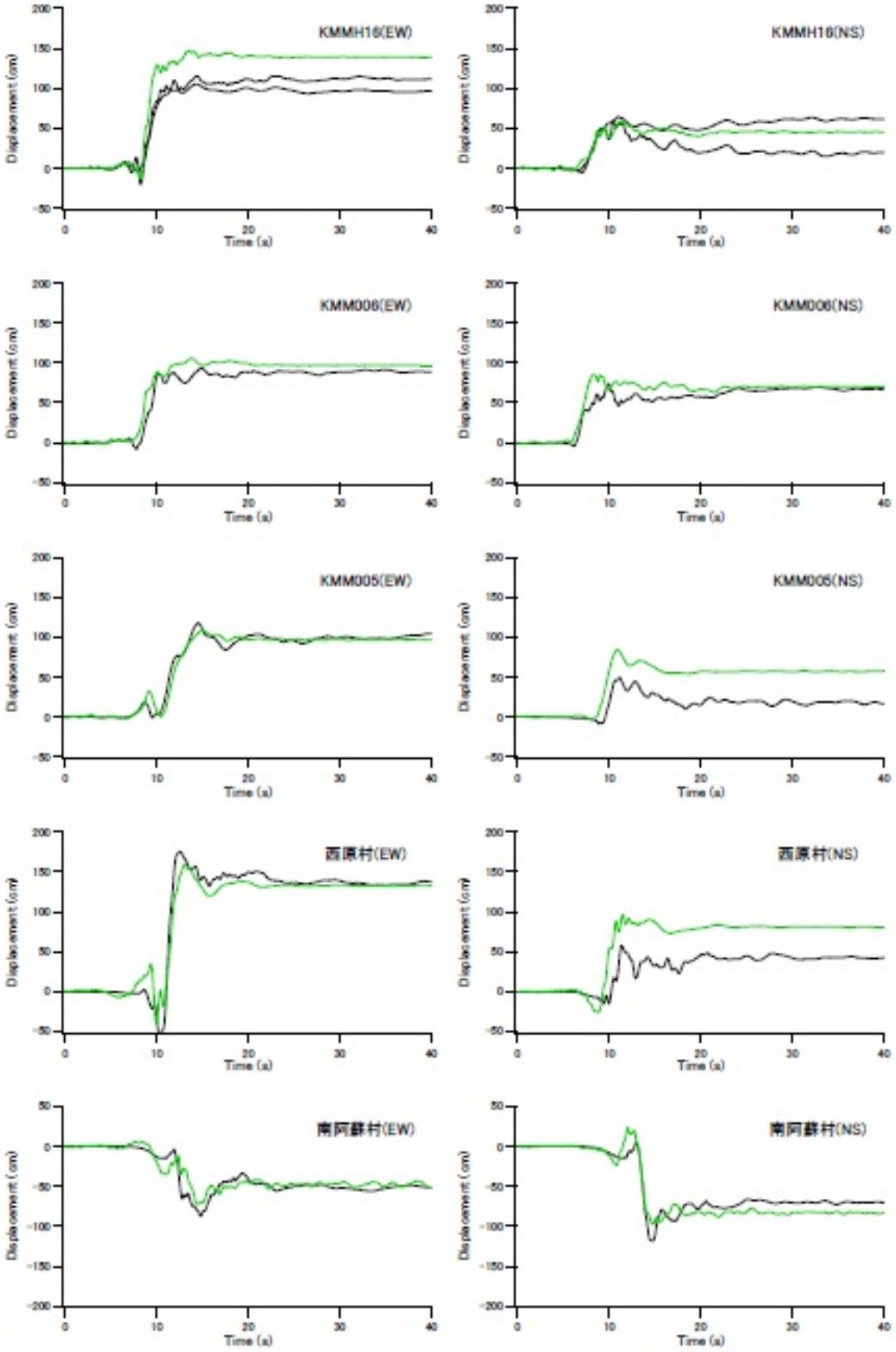

背景領域＋アスペリティを考慮した変位波形の計算結果（黒が観測，緑が計算）（原点は気象庁の発震時刻）

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Fling-steps displacements by the discrete wavenumber method

*SHUANGLAN WU[1], Atsushi Nozu[1], Yosuke Nagasaka[1]

1. PORT AND AIRPORT RESEARCH INSTITUTE

The discrete wavenumber method introduced by Bouchon (1977, 1981, 2003), provides a way to accurately calculate the complete Green’ s functions for many problems with a minimum amount of mathematics, and it is appropriate to represent the seismic waves by the summation of plane waves in the wavenumber domain for each frequency. However, there are still some problems to be solved by adoption of this approach in several specific cases. For example, the effects of imaginary part of complex frequency and the truncation of wavenumbers on near-fault fling-steps displacements.
For the first one, it advantages that a complex frequency with a small positive imaginary part is introduced in Bouchon (Bouchon, 1979) to solve the problem of integrand becomes zero when obtaining the near-fault ground motions. The determination and effects of the imaginary part of the complex frequency as defined by $\omega_c=\omega-\lambda i$, the values of λ in the range of $\lambda=[\pi/2T\omega,\ \pi/T\omega]$ recommended by Bouchon (2003) is still not clear. Therefore, in order to obtain more accuracy displacement waveforms, trail and errors have been conducted on near-fault fling-steps displacements under various point source models and it resulted that, $\lambda=2\pi/T\omega$ rather than $\lambda=\pi/T\omega$ can be recommended, (the displacement waveforms of dip-slip case under various could be obtained in Figure 1 below).
In terms of the second parameter, since for the near-fault displacements, in which seismic source and stations are located at a nearly same depth or at very low frequency range, the convergence of integration or summation over wavenumbers becomes very slow, the truncation of wavenumbers in such a case should be determined carefully. The use of $k_{max}=4k_{\alpha}$ was recommended (Bouchon and Aki, 1977), where $k_{\alpha}=\omega/\alpha$ and α stands for the P wave velocity. And the pioneering work of Honda and Yomogida (2003) addressed the issue of appropriately setting this parameter for the simulation of fling-step displacements by testing the accuracy of the fling-step displacements calculated through the DWN method by comparing the results with the analytical solutions for the static displacements (Okada, 1985) and proposed to use $k_{max}=4\ km^{-1}$ in the low frequency range. However, their study was focused on cases where a large amount of seismic moment is released at several kilometers under the surface. In this research, aimed at establishing a criteria for the k_{max} value applicable even for the shallow slip cases, based on the solutions in complete elastic wavefield, the truncation wavenumber was deduced related to the source depth dependent theoretically. And $k_{max}=5\pi/Z_s$ was recommended, where Zs is the depth of the source. The criteria for k_{max} was fully verified in the various point source model and the resultant displacements showed good agreements with analytical solutions (Okada (1985), which are illustrated in the following Figure 2).

Keywords: fling-steps displacements, discrete wavenumber method, complex frequency, point source depth dependent truncate number of the wavenumber integration, point source models

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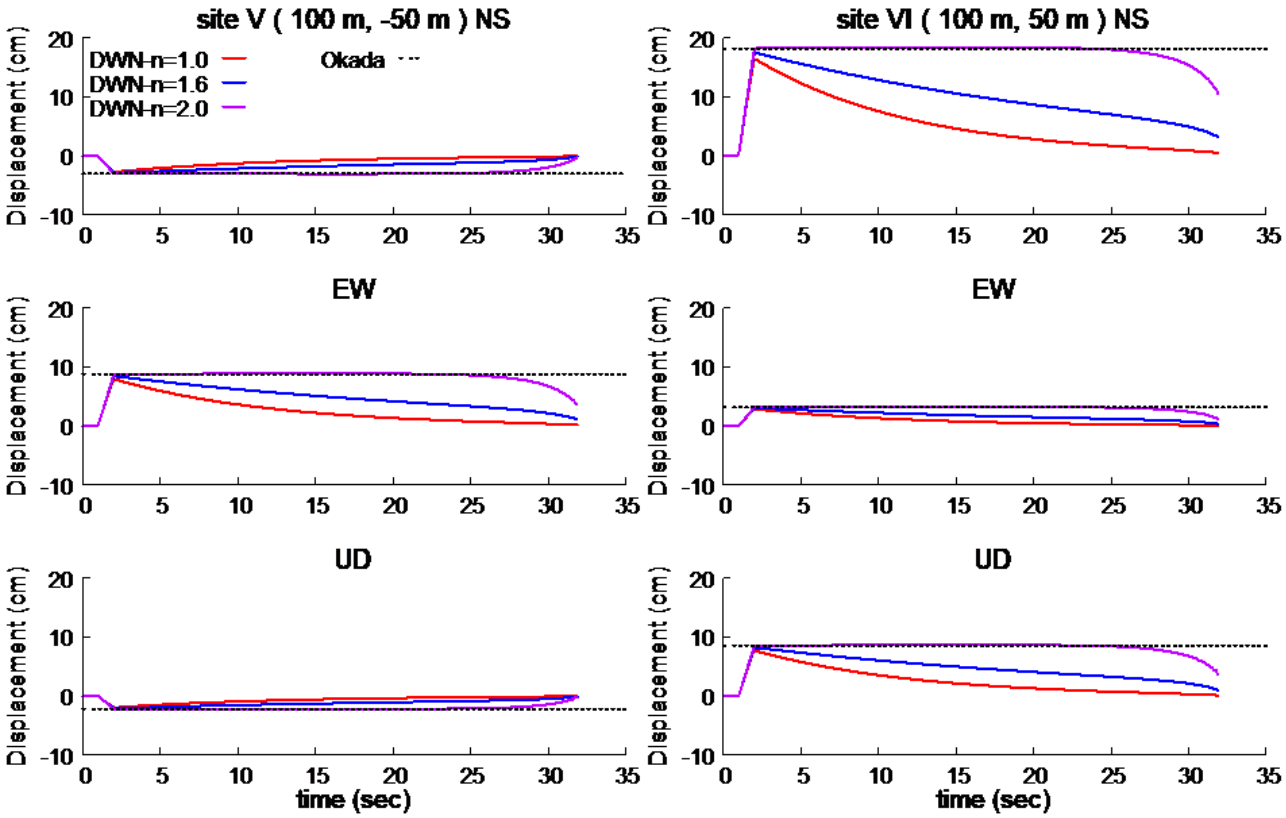

Figure 1 Dip-slip (dip45°): effects of complex frequency (i.e., n-value) on the near-fault fling-steps displacement

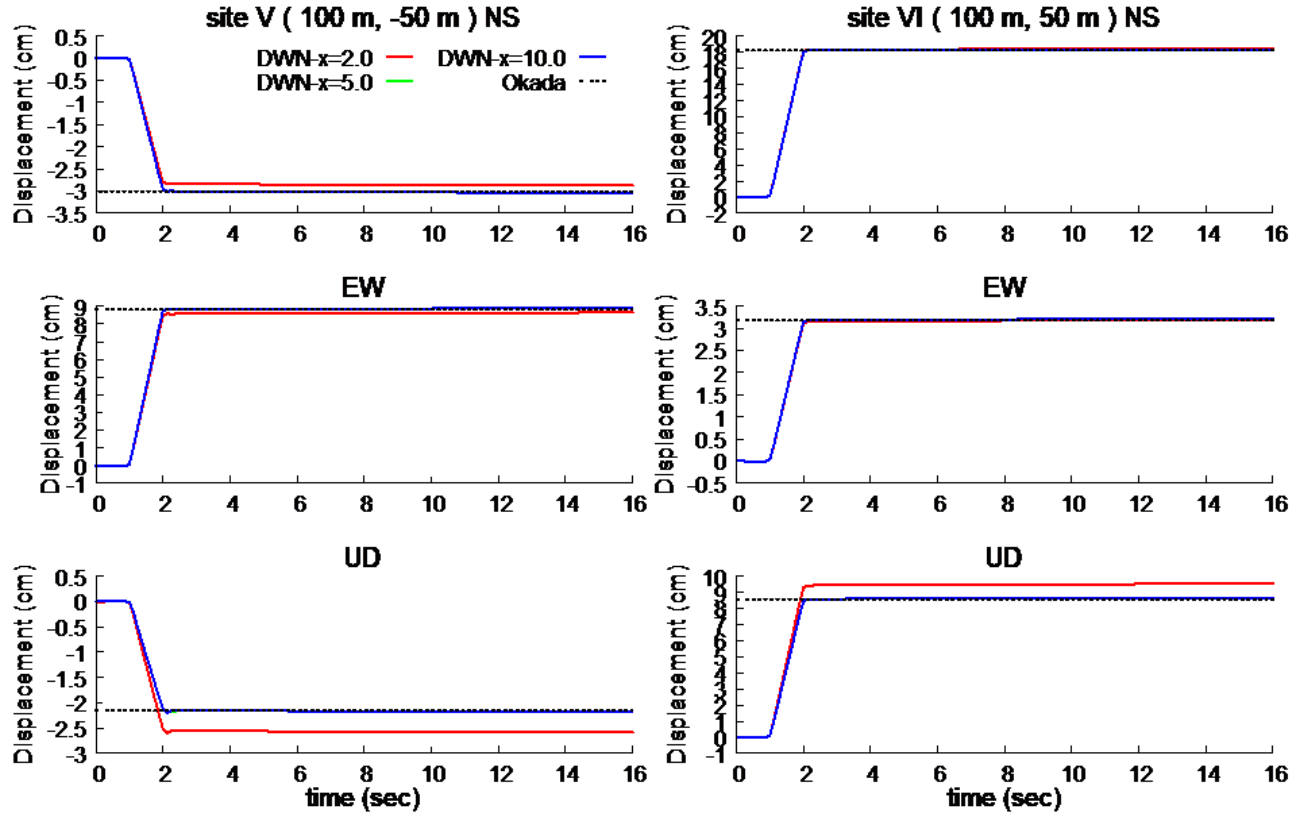

Figure 2 Dip-slip (dip45°): effects of point source depth dependent truncate wavenumber (i.e., x-value) on fling-steps displacements

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Extension of characterized source model for long-period strong motions near surface-rupture-earthquakes

*Kojiro Irikura[1], Susumu Kurahashi[1], Yasuhiro Matsumoto[2]

1. Aichi Institute of Technology, 2. KOZO_KEIKAKU Engineering, Inc.

Introduction: Strong ground motions from the 2016 Kumamoto earthquake (Japan) were well simulated based on the characterized source model consisting of strong-motion-generation-areas (SMGAs) with high stress drop and a background area with low stress drop except very-near fault stations (Irikura et al., 2017). Strong ground motions observed at very-near-fault stations less than 3 km away from the surface traces along the Futagawa fault zone have specific long-period motions including maximum permanent displacements beyond 2 m. To reproduce long-period ground motions at those very-near-fault stations, we need not only to put SMGAs but also to add long-period motion generation areas (LMGAs) in surface layers from fault surface to a certain depth above the seismogenic zone. During the 2010 Mw7.1 Darfield earthquake (New Zealand), surface breaks caused by the mainshock were found associated with active faults by field surveys. Strong ground motions from the 2010 Darfield earthquake were also simulated well using the conventional characterized source model except ground motions at very-near fault stations. Reproduction of very-near-fault motions with permanent components for the 2010 Darfield earthquake are also needed to take into account LMGAs in surface layers. The same phenomena have been observed in the 2011 Nagano-ken Hokubu earthquake (Mw 6.2), the 1999 Chi-Chi earthquake (Mw 7.6), and other surface-rupture earthquakes as long-period motions and permanent displacements seen in the 2016 Kumamoto and 2010 Darfield earthquakes Then, we propose the extension of the characterized source model adding long-period motion generation areas (LMGAs) from fault surface to a certain depth above the seismogenic zone. The parameters for SMGAs are given following the recipe by Irikura and Miyake (2010). The parameters of LMGAs are discussed in relation to scaling relationships of surface-rupture earthquakes.

Extension of characterized source model: Long-period motions with permanent displacements at the very-near-fault stations during the 2016 Kumamoto earthquake are not well simulated based on the conventional characterized source model. SMGAs in the conventional characterized model were determined inside the seismogenic zone deeper than 3 km. To generate long-period motions near the fault traces, long-period motion generation areas (LMGAs) are deployed in surface layers from fault traces down to a certain depth. Similar studies have been made by several authors (e.g. Ikutama et al. 2017; Tanaka et al., 2018; Satoh, 2018; Iwaki et al., 2018). Ground motions more than 2 s observed at very-near-fault-distance stations such as 93048 (Nishihara Village Hall), 93051 (Mashiki Town Hall), KMMH16 (Mashiki-KiK-net station) in the 2016 Kumamoto earthquake are well reproduced adding long-period motion generation areas (LMGAs). During the 2010 Mw7.1 Darfield (New Zealand), surface breaks caused by the mainshock were found associated with active faults by field surveys. Strong ground motions from the 2010 Darfield earthquake were also simulated well using the conventional characterized source model except ground motions at very-near fault stations. Reproduction of very-near-fault motions with permanent components for the 2010 Darfield earthquake are also needed to take into account LMGAs in surface layers. To determine the extended characterized source model for strong motion prediction of target earthquakes, first the procedures for estimating the outer and inner fault parameters are preserved for the SMGAs. Next, to set LMGAs for the target earthquake, L_b (Length of LMGA), W_b (Width of LMGA), D_b (Maximum slip of LMGA), T_b (rise time of slip velocity time, function) are systematically given, following scaling relationships for surface-rupture earthquakes.

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This study was supported in part by the Grants-in-Aids for Scientific Research (B) (P.I.: Hidenori Kawabe, Grant number: 16H03144) from the Ministry of Education, Culture, Sports, Science and Technology and the 2017 research project ‘Examination for uncertainty of strong ground motion prediction for the inland crustal earthquakes’ by the Secretariat of the Nuclear Regulation Authority (NRA), Japan.

Keywords: strong ground motions, characterized source model, strong-motion generation area, long-period motion generation area

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A Study for the cause of earthquake damages by the 2014 Nakagano-ken Hokubu earthquake (M_J 6.7) –consideration using the strong motion simulation –

*Kazuhito Hikima[1], Ryoichi Nakamura[2], Tomiichi Uetake[1]

1. Tokyo Electric Power Company Holdings, Inc., 2. Earthquake Research Institute, Univ. of Tokyo

- INTRODUCTION -

During the 2014 Nagano-ken Hokubu earthquake, distinct surface ruptures were observed along the known Kamishiro fault, so it suggests that fault slip was occurred near the shallow parts on the fault plane. However, the damage caused by strong motion was not so heavy near Shiojima district, where the most distinct surface rupture was observed, and the fatal damage befall around Horinouchi district, where locate at 7 to 8 km south from Shiojima. To study the reason of the discrepancy among these damages and the fault slip is important for understanding the cause of strong motions.
In previous study (Hikima *et al.*, 2015: SSJ, 2018:JpGU), we carried out source process inversion using strong ground motion records. In this study, we performed the strong motion simulation using the derived source model and the 3D structure model and discussed the cause of the strong ground motions and the damages.

- SOURCE MODEL -

The outline of the source model by Hikima *et al.* (2018) is as follows.
Basically, the waveforms of KiK-net borehole stations (by NIED) within about 50 km from the source area were used for the analysis. The acceleration waveforms were filtered between 0.03 and 0.8 Hz, and were integrated to velocity waveforms for the inversion analysis. In addition, two displacement waveforms at K-NET Hakuba (NGN005) and KiK-net Hakuba (NGNH36), which were adequately integrated from acceleration waveforms (Nakamura *et al.*, 2015:SSJ), were also incorporated to the analysis.
The source process was inverted by the multi time window analysis (Yoshida *et al.*, 1996, Hikima, 2012). We calculated the Green's functions by 3D finite difference method using a 3D velocity structure model. The 3D velocity structure was taken from the model constructed for the long period ground motion prediction map by the HERP.
The parameters of the hypocenter were taken from Sakai *et al.* (2015). Although the strike of the fault plane was set as 25 degree in Hikima *et al.* (2018), we also consider other strike angles in this study. The dip angle was varied according to depth, and the values were 60 and 50 degree for deep and shallow part, respectively. The fault size was 19 km for length and 15 km for width. The subfault size was 1.0km. Some large slip areas were estimated on the fault plane. One was slightly deeper from the hypocenter and the other one was on the shallow and small part of the fault plane. Although the amount of final slip was similar on these area, the time functions on shallow part were broader than those on deeper part, so it suggests that the strong motions from the shallow portion relatively lack high frequency components than those from deeper parts. Furthermore, large slip was not estimated on the fault plane near Horinouchi district.

- STRONG MOTION SIMULATION -

The strong motion simulation was performed by 3D finite difference method using the inverted source model and the 3D velocity structure. We used finer grid spacing than the calculation for the Green's function to consider higher frequency.

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Although large PGV values were calculated near the region where the surface rupture was emerged, almost same level strong motions were estimated also near the Horinouchi. To survey the reason of these strong motions, we checked the snap shots and found that the directivity effect from the large slip which lies on the shallow part of the fault. Furthermore, when the amplification by the surface geology was also considered, the amplitude around Horinouchi became larger than the region near Shiojima and so on. It seems that the results correspond to the observed damage distribution in the source region. From these results, we think that the causes of the strong ground motion around Horinouchi are the source process (directivity effect) and the amplification by the surface geology.

Keywords: 2014 Nagano-ken Hokubu earthquake, Strong motion simulation, Source process, Near fault ground motion

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Convention Hall A 2F

[S-SS13] Strong Ground Motion and Earthquake Disaster

convener:Masayuki Kuriyama(Central Research Institute of Electric Power Industry), Kazuhiro Somei(Geo-Research Institute), Chairperson:Yosuke Nagasaka(Port and Airport Research Institute), Masumi Yamada(Disaster Prevention Research Institute, Kyoto University)

Strong ground motion has social impacts as it induces earthquake disasters. We solicit contribution on any seismological topics related to strong ground motion that includes, but are not limited to, source processes, wave propagation, and site effects. We also welcome contribution on earthquake related disaster mitigation.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SSS13-19] Strong ground motion simulation of the Northern Osaka earthquake of June 18, 2018

*Yosuke Nagasaka[1], Atsushi Nozu[1] (1.Port and Airport Research Institute)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SSS13-20] **Strong Motion of the 2018 Mw 6.4 Hualien, Taiwan Earthquake and Its Impact on Seismic Design Code in Taiwan**

*Chun-Hsiang Kuo[1], Jyun-Yan Huang[1], Che-Min Lin[1], Kuo-Liang Wen[2] (1.NCREE National Center for Research on Earthquake Engineering of Taiwan, 2.NCU National Central University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SSS13-21] Simulation of Rupture Directivity Effect for the February 6, 2018 Hualien, Taiwan Earthquake

*Cheng-Feng Wu[1], Huey-Chu Huang[1] (1.Department of Earth and Environmental Sciences, National Chung Cheng University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SSS13-22] Strong motions and estimation of the sursurface soil structure for the 2018 Hualien earthquake in Taiwan

*Masumi Yamada[1], Ikuo Cho[2], Chun-Hsiang Kuo[3], Che-min Lin[3], Ken Miyakoshi[4], Yujia Guo[4], Takumi Hayashida[5], Yasuhiro Matsumoto[6], James Mori[1], Yin-Tung Yen[7], Keng-Chang Kuo[8] (1.Disaster Prevention Research Institute, Kyoto University, 2.National Institute of Advanced Industrial Science and Technology , 3.National Center for Research on Earthquake Engineering, 4.Geo-Research Institute, 5.Building Research Institute, 6.Kozo Keikaku Engineering, 7.Sinotech Engineering Consultants, 8.Kaohsiung university of Science and Technology)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SSS13-23] **Effect of Near Surface Geology on the Recorded Ground Motion of the Nepal Earthquake in Kumaon Himalaya**

*SOHAN LAL[1], Anand Joshi[1], M.L. Sharma[1] (1.Indian Institute of Technology Roorkee)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SSS13-24] Broadband Source Modeling for the Himalayan Collision Zone

*Hiroe Miyake[1], Babita Sharma[2], Kazuki Koketsu[1], Soma Nath Sapkota[3] (1.Earthquake Research Institute, University of Tokyo, 2.National Centre for Seismology, Ministry of Earth Sciences, India, 3.Department of Mine and Geology, Nepal)

Strong ground motion simulation of the Northern Osaka earthquake of June 18, 2018

*Yosuke Nagasaka[1], Atsushi Nozu[1]

1. Port and Airport Research Institute

Strong ground motion simulation with point source model is simpler than the model with rectangular asperities. On the other hand, if the point source model ignores spacio-temporal extension of the fault, this can cause discrepancy between observation and synthetics. We have examined the applicability of the pseudo point-source model (Nozu, 2012) for intraslab earthquakes and so on and the results showed good agreement with observation records. However, validation of the method for crustal earthquakes is not enough. In this study, we conducted strong ground motion simulation for the June 18, 2018 Northern Osaka earthquake (M_J6.0) as an example of crustal earthquake.

First we assumed two fault planes based on moment tensor solution and aftershock distribution. These two fault planes have the mechanism of reverse fault and right-lateral slip fault, respectively. Then we estimated slip distribution by general inversion technique using empirical Green's functions. The result was that the reverse fault first ruptured and the right-lateral fault ruptured after a while, larger slip was seen on the reverse fault.

We then conducted strong ground motion simulation with the pseudo point-source model. In the method, we regard one asperity as one point source that follows omega-square model. We get the synthetic waveforms by combining the omega-square model with path spectrum, empirical site amplification factor, and site phase characteristics for each target station. We assumed only one point source in the first case. We put the point source on the hypocenter, and determined seismic moment (1.7×10^{17} Nm) and corner frequency (0.65 Hz) so that the synthetic Fourier spectra explain observed spectra the best. For phase characteristics, we chose the earthquake of June 19, 2018 occurred at 4:53 (M_J3.9). This small earthquake has the mechanism of reverse-fault, which explained the observed phase characteristics better than the phase of right-lateral earthquake. The result with one point source showed good agreement with observations in terms of amplification and phase characteristics. However, the result underestimated at OSK002, the closest station from the epicenter.

In order to improve this problem, we then conducted the simulation with two point sources, which can better consider the effect of the rupture propagation than the case of one point source. The location of the second point source is about 0.3km above the first point source. The relative rupture time is 0.41s. We used the same small earthquake for phase characteristics for both point sources. The seismic moments and corner frequencies were determined in the same manner as the case of one point source as M1=0.7×10^{17}Nm, fc1=0.6Hz, M2=1.1×10^{17}Nm, fc2=0.9Hz. As a result, the amplification at OSK002 was improved and the characteristics of the Fourier spectra were also improved compared to the one point source case.

Keywords: 2018 Northern Osaka earthquake, Strong ground motion simulation, point source model

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Strong Motion of the 2018 Mw 6.4 Hualien, Taiwan Earthquake and Its Impact on Seismic Design Code in Taiwan

*Chun-Hsiang Kuo[1], Jyun-Yan Huang[1], Che-Min Lin[1], Kuo-Liang Wen[2]

1. NCREE National Center for Research on Earthquake Engineering of Taiwan, 2. NCU National Central University

The maximum observed PGA and PGV at various stations during the 2018 Hualien, Taiwan earthquake were 594 Gal and 146 cm/s, respectively. Pulse-like velocities were observed at all stations within a distance of 4 km from the Milun fault. The horizontal spectral accelerations of the pulse-like records indicated two obvious amplifications at periods of roughly 1 s and 2 s. Natural frequencies of 0.8 to 1.5 Hz were observed in the region near the Milun fault using microtremor measurements. The spectral acceleration peak at periods of roughly 2 s is mostly seen in the east-west direction, indicating a typical fault-normal seismic radiation from the fault rupture. Consequently, we contend that the amplifications of spectral acceleration at approximately 1 and 2 s were caused by site amplification and the rupture front, respectively. The site amplification at the period of approximately 1 s may have been one reason for the collapse of medium-rise buildings during this earthquake. Evident soil nonlinearity resulted in smaller horizontal than vertical PGA at many stations in the near-fault region. Return period of the Milun Fault is believed to be about 67 years (1951 and 2018) and thus it is a 53% probability of being exceeded in a 50-yr mean recurrence interval. The demand of seismic design in the Hualien City will have to be increased especially in the long-period according to the observed ground motions during this earthquake.

Keywords: Near-Fault Ground Motion, PGV, Pulse-like Velocity

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Simulation of Rupture Directivity Effect for the February 6, 2018 Hualien, Taiwan Earthquake

*Cheng-Feng Wu[1], Huey-Chu Huang[1]

1. Department of Earth and Environmental Sciences, National Chung Cheng University

The Hualien earthquake (M_W 6.4) occurred off Taiwan’s eastern coast on February 6, 2018. This earthquake has struck the eastern Taiwan and also caused several houses collapsed and casualties. From the observed strong motion data at the disaster sites, an obvious directivity pulse appears in the velocity waveform and the peak ground velocity (PGV) exceeds 50 cm/s. In order to further investigate the strong ground motion characteristics of this earthquake, we perform the broadband (0.1-10 Hz) strong ground motion simulation using the stochastic Green's function method. About the source parameters, we adopt the empirical formulas. Besides, the slip distribution on the fault plane is calculated by using the hybrid k-squared slip model. By comparing the simulation results with the observed data, we get the best slip model from the hypothetical slip models. Moreover, we effectively simulate the directivity pulses at several stations at the south of the earthquake. The disaster areas are located near and above the asperity of the fault plane. According to simulation results of different velocity structures, the addition of the shallow velocity structure makes the synthetic waveforms more similar to the observed data at most stations. The amplifications of the PGVs are about a factor of 2.0 at the stations near the disaster areas. Therefore, the disasters of the Hualien earthquake could be caused by the forward-directivity and site amplification effects.

Keywords: Hualien earthquake, ground motion simulation, stochastic Green's function method, hybrid k-squared slip model

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Strong motions and estimation of the sursurface soil structure for the 2018 Hualien earthquake in Taiwan

*Masumi Yamada[1], Ikuo Cho[2], Chun-Hsiang Kuo[3], Che-min Lin[3], Ken Miyakoshi[4], Yujia Guo[4], Takumi Hayashida[5], Yasuhiro Matsumoto[6], James Mori[1], Yin-Tung Yen[7], Keng-Chang Kuo[8]

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The 2018 Hualien earthquake occurred around 23:50, February 6, 2018 (local time). The depth of the event was about 10 km and the moment magnitude was 6.4 (USGS). Crustal deformation in the Hualien basin was clearly observed in the InSAR image (e.g., GSI 2018, Hashimoto 2018). The rupture propagated along the Milun fault from north to south and the northern part of the Longitudinal Valley fault was also ruptured. Particularly, the discontinuity of the interference fringes at the Milun fault was clear on the InSAR image.

In Hualien city, the middle-rise four buildings collapsed during the earthquake, due to the collapse of the pillars at the first floor. They were located at the place where discontinuous fringes were observed in the InSAR images. There is a possibility that the discontinuous displacements or ground motions in the vicinity of the fault affect on the damage of the buildings (NARlabs 2018).

In order to understand the cause of building damage in Hualien city and the heterogeneous subsurface soil structure in the Hualien basin, we performed microtremor array measurement on October 20-26, 2018. We performed the measurement at every 100-200 m along the EW section of the basin. At each measurement point, we used 5 seismometers to obtain the phase-velocity dispersion curves at the shallow subsurface structure. In total, we measured microtremors at 64 observation points and obtained the phase-velocity dispersion curves and H/V spectra.

Our profile shows that the peak of the H/V spectra is about 1-2 Hz along the measurement line, which probably corresponds to the basement at the depth of 50-100m. The average Vs at the depth of 10-30m is about 200-400 m/s. There is a clear difference between the east and west side of the Milun fault: at the west side of the fault, there is a soft soil deposit on the shallow surface (10m) with the average Vs less than 200m/s. At the east side of the fault, the soft layer with the Vs<400m/s is very thin. Therefore, we estimated the engineering bedrock of the west side of the Milun fault is deeper than the east side. This difference of the basin thickness is consistent with the movement of the Milun fault during the 2018 Hualien earthquake estimated from the InSAR image.

Keywords: Hualien earthquake, Strong motion, Subsurface soil structure, Microtremor

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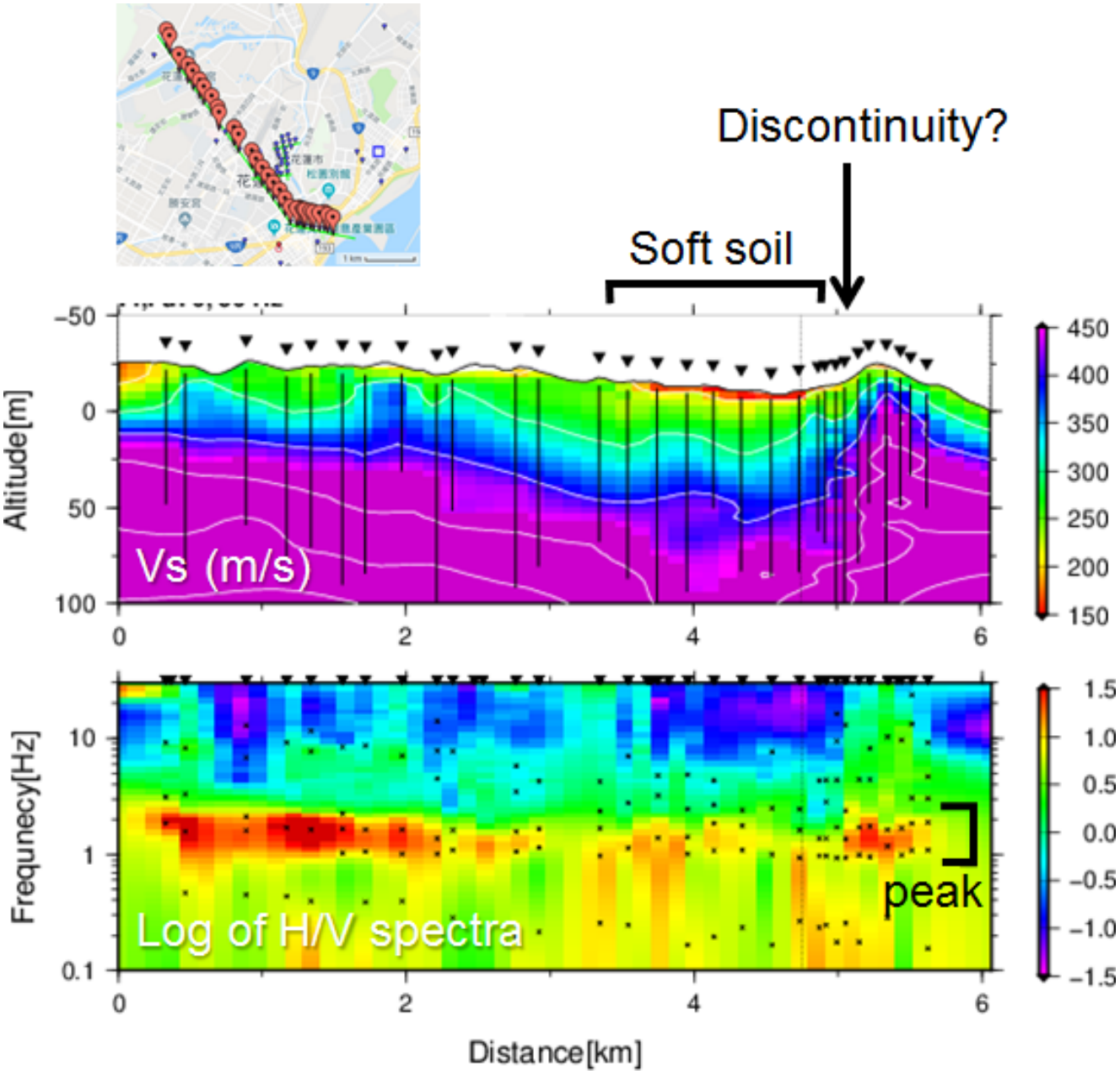

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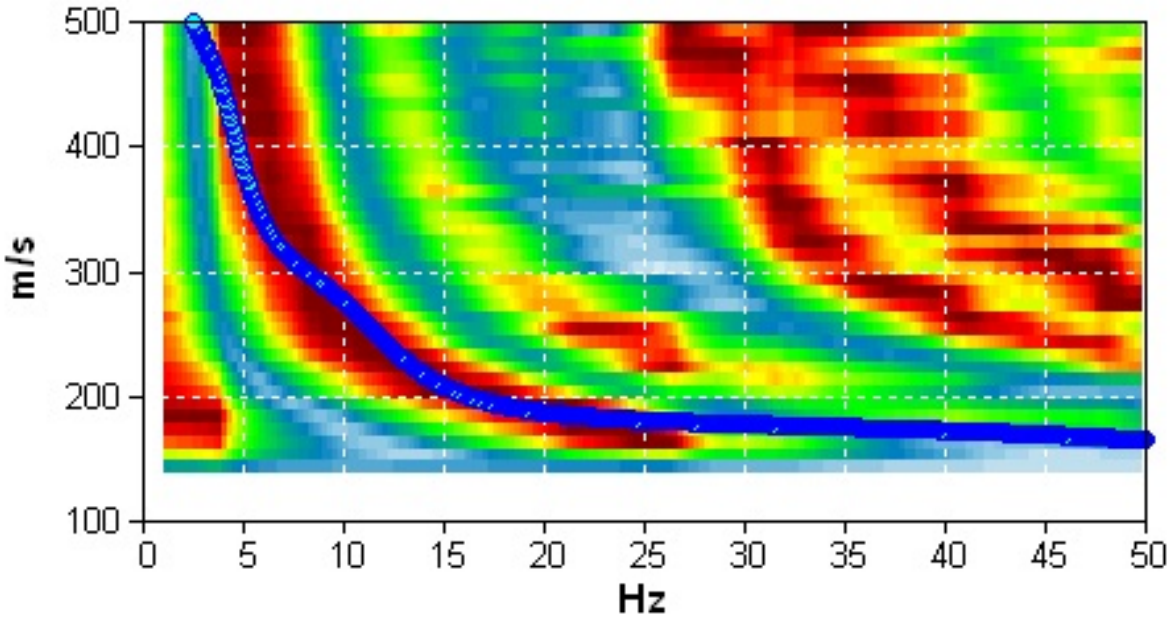
Effect of Near Surface Geology on the Recorded Ground Motion of the Nepal Earthquake in Kumaon Himalaya

*SOHAN LAL[1], Anand Joshi[1], M.L. Sharma[1]

1. Indian Institute of Technology Roorkee

An earthquake has been devastated the Nepal on 25 April 2015. The earthquake experienced the low frequency amplification. The subsurface structure alters the seismic wave through which they propagate and can amplify or de-amplify the amplitude of the coming wave from the source for the frequency ranges. The Nepal earthquake was been recorded at the Kumaon Himalaya region at the western side from the epicenter. The present paper highlights the effect of local geology on the recorded ground motion and calculation the shallow subsurface velocity model using the joint fit of the surface wave dispersion curve and HVSR ratio. The theoretical transfer function generated which satisfy both the dispersion curve and the HVSR ratio is directly convolve with the hard rock simulated time series to calculate the surface simulation. The simulation of the Nepal earthquake was done using the semi- empirical technique.

Keywords: Site effect, Strong ground motion, Simulation



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Broadband Source Modeling for the Himalayan Collision Zone

*Hiroe Miyake[1], Babita Sharma[2], Kazuki Koketsu[1], Soma Nath Sapkota[3]

1. Earthquake Research Institute, University of Tokyo, 2. National Centre for Seismology, Ministry of Earth Sciences, India, 3. Department of Mine and Geology, Nepal

The Himalayan collision zone is characterized by the significant tectonic setting. There are earthquakes with low-angle thrust faulting as well as continental outerrise earthquakes. Recently several historical earthquakes have been identified by active fault surveys [e.g., Sapkota et al., 2013]. We here investigate source scaling for the Himalayan collision zone as a fundamental factor to construct source models toward seismic hazard assessment. As for the source scaling for collision zones, Yen and Ma [2011] reported the subduction-zone source scaling in Taiwan, and pointed out the non-self-similar scaling due to the finite crustal thickness. On the other hand, current global analyses of stress drop do not show abnormal values for the continental collision zones [e.g., Allmann and Shearer, 2009]. Based on the compiled profiling of finite thickness of the curst and dip angle variations, we discuss whether the bending exists for the Himalayan source scaling and implications on stress drop that will control strong ground motions. Due to quite low-angle dip faulting, recent earthquakes in the Himalayan collision zone fit the upper bound of the current source scaling of rupture area vs. seismic moment (< Mw 8.0), and do not show significant bending of the source scaling. Toward broadband source modeling for ground motion prediction, we perform empirical Green’s function simulations for the 2009 Bhutan and 2015 Gorkha earthquake sequence to quantify both long- and short-period source spectral levels [e.g., Miyake et al., 2017; Sharma et al., 2018].

Recent Himalayan events showed the upper bound of the current source scaling of rupture area vs. seismic moment (< Mw 8.0), and current plots well match with Somerville et al. (1999) without bending. However, re-estimates of maximum fault width may change the source scaling. We also found that Himalayan events less than M6-class follow crustal earthquake scalings for short-period ground motion generation. If M7-class sources are modeled to follow crustal earthquake scalings, simulated ground motions tend to be larger than GMPEs on rock. Short-period ground motion saturation will be validated after broadband ground motion modeling for more events (e.g., Gorkha aftershocks).

Keywords: Himalayan collision zone, broadband source model, scaling, 2015 Gorkha earthquake

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Yoshiyuki Tanaka(Earth and Planetary Science, The University of Tokyo), Masayuki Kano(東北大学 大学院理学研究科 地球物理学専攻)

Study of crustal deformation plays an extremely important role in the investigation of wide scale earth dynamics those are earthquake and volcanic activity, plate motion and so on. In our session, we discuss the study related to crustal deformation, such as development of observation instrument, observed crustal deformation, analysis method, and simulation study.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SSS16-01] Development of New GEONET Analysis Strategy

*yasuaki kakiage[1], satoshi abe[1], kazuyuki ohashi[1], hideo hamazaki[1], kazuyuki tanaka[1], satoshi kawamoto[1], yuki hatanaka[1] (1.GSI of Japan)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SSS16-02] Relationship between deformation of the forearc wedge of Southwest Japan and the 1707 Hoei earthquake

*Yukinobu Okamura[1], Masanobu Shishikura[1] (1.Research Institute of Earthquake and Vocano Geology, National Institute of Advanced Industrial Science and Technology)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SSS16-03] A possible slow slip event beneath the Kii Peninsula inferred from historical tilt records in 1970's

*Masayuki Kano[1], Yasuyuki Kano[2] (1.Graduate school of science, Tohoku University, 2.Earthquake Research Institute, The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SSS16-04] The effect of the steady plate subduction in the case of southwest Japan

*Yuto Iwase[1], Takeo Ito[1] (1.Graduate School of Environmental Science, Nagoya University)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SSS16-05] Development of Mechanical Coupling Model on Subducting Plate Interfaces

*Hiroshi Kimura[1], Takeo Ito[1], Keiichi Tadokoro[1], Ryohei Sasajima[2] (1.Department of Earth and Planetary Sciences, Nagoya University, 2.Research Center For Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SSS16-06] Monitoring vertical deformation with optical lattice clock –an application of relativistic geodesy

*Yoshiyuki Tanaka[1], Yuichi Imanishi[2], Yoshiaki Tamura[3] (1.Earth and Planetary Science, The University of Tokyo, 2.Earthquake Research Institute, The University of Tokyo, 3.Mizusawa VLBI Observatory, National Astronomical Observatory of Japan)

Development of New GEONET Analysis Strategy

*yasuaki kakiage[1], satoshi abe[1], kazuyuki ohashi[1], hideo hamazaki[1], kazuyuki tanaka[1], satoshi kawamoto[1], yuki hatanaka[1]

1. GSI of Japan

Geospatial Information Authority of Japan (GSI) has been operating GEONET (GNSS Earth Observation Network System), which involves over 1,300 GNSS stations, since 1996. The daily coordinates for each station are estimated by Bernese GNSS software to monitor the crustal deformation in Japan. The analysis strategy was updated four times. Current version is the fourth generation (4G) analysis, which was developed in 2009. We are now developing a new strategy (5G) because the software, reference frame, and other physical models used in 4G analysis have been obsolete. Major features of 5G analysis are: 1. Update of reference frame, 2. GPS and GLONASS integration, 3. Improvement of the troposphere model, 4. More stable daily coordinates of the reference station (TSUKUBA-1) for analysis. GSI developed 5G prototype in 2017.
The 5G prototype firstly conducts “fix-point analysis” to estimate daily coordinates of TSUKUBA-1. Then all other stations are estimated using GPS and GLONASS data individually. Finally, the GPS and GLONASS solutions are integrated.
The daily coordinates of the TSUKUBA-1 is estimated by a global analysis using worldwide IGS stations under No-Net-Translation constraint. But, we analyzed the data from 1996 to 2004 constraining IGS stations coordinates(SINEX results) directly.
In case of all other GEONET analysis, there is limiting condition to solve combined solution. So we evaluate the combined solutions with respect to limiting condition.
We will show the in detail of fix point analysis and 5G analysis, especially combine solution.

Keywords: Geodesy

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Relationship between deformation of the forearc wedge of Southwest Japan and the 1707 Hoei earthquake

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1. Research Institute of Earthquake and Vocano Geology, National Institute of Advanced Industrial Science and Technology

We propose a hypothesis that the deformation of the forearc wedge of Southwest Japan and wide varieties of plate boundary earthquakes along the Nankai Trough have been caused by oblique subduction of the undulating Philippine Sea Plate (PSP). Interseismic and coseismic deformations of the forearc wedge of Southwest Japan have been observed by geodetic measurements, however, these deformations have not been accumulating. In contrast, N-S trending uplift zones, namely the Akaishi and Kii mountains, have been growing during the Quaternary periods. The mountains correspond to the zones of PSP trending in NE-SW and the subsiding areas of the Kii strait and Ise Bay to Nobi plain are located above the NW-SE to E-W trending PSP. If the axes of undulations of the subducting slab have been fixed to the PSP, the depth of the PSP trending in NE-SW have been decreasing and that of the PSP trending in NW-SE to E-W have been increasing. The uplifting and subsiding zones correspond to the area of plate depth decrease and increase respectively, thus we infer that the vertical movements of the forearc wedge have been caused by the change of the plate depth. Relative sea level change shown by uplifted sessile assemblage have indicated that uplift during the 1707 Hoei earthquake has been accumulated while those of 1854, 1944 and 1946 plate-boundary earthquakes have not. This fact strongly suggests that there is a strong coupling zone lasting for several hundred years under the Kii Peninsula, and that the break of the coupling triggers the Hoei-type earthquake that ruptured the entire plate boundary. We also point out the possibility that there is another coupling zone under the Akaishi Mountains. The deformation of the forearc wedges of the Southwest Japan and differences of rupture patterns of the plate boundary along the Nankai Trough can be attributed to the change of the depth of the PSP.

Keywords: Nankai Trough, crustal movement, Philippine Sea Plate, 1707 Hoei earthquake

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A possible slow slip event beneath the Kii Peninsula inferred from historical tilt records in 1970’s

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Slow slip events (SSEs) have been often observed prior to large earthquakes such as the 2011 Tohoku-oki earthquake and the 2014 Iquique earthquake (e.g., Kato et al., 2012; Mavrommatis et al., 2014; Ruiz et al., 2014). In addition, numerical studies demonstrated that intervals of SSEs became shorter in the latter half of the interseismic period (e.g., Matsuzawa et al., 2010). Therefore, activities and variations of SSEs in time and space provide important clues to anticipated large earthquakes.

Many studies have investigated activities of SSEs based on dense geodetic observation networks established in the early 2000’s (e.g., Sekine et al. 2010; Nishimura et al. 2013). On the other hand, there are few reports before the establishment of such dense networks (Kimata et al., 2001; Kobayashi and Yamamoto, 2011). Here, we report a possible SSE beneath the Kii Peninsula based on historical tilt records in 1970’s.

We used tilt data recorded in Kishu observatory in the Mie Prefecture operated by Kyoto University. Horizontal-pendulum tiltmeters were installed in directions of N57W and N33E. The original tilt data was drawn on bromide (light-sensitive) papers, each of which consists of tilt records for about one week. We have digitized bromide records in 1970’s and connected to a single continuous record.

In the late November in 1973, there was a slow tilt change of >0.5 μrad down to the northeast that lasted for a few days. Assuming that this crustal deformation was due to an SSE along the plate boundary, we have constructed a possible model of SSE. Because it is difficult to constrain fault parameters from a single station record, we conducted a forward modeling assuming already known SSE models beneath the Kii Peninsula obtained by Nishimura et al. (2013). Among 42 template fault models from 1996 to 2012, 3 models were able to qualitatively explain the direction of tilt changes. The centroids of these fault models locate ~30-50 km western side of the observatory. However, the calculated tilt change was about one order smaller than the observed one. Therefore, it is possible that the amount of slip was greater than the template models or the location of SSE was closer to the observatory.

Around the source area, relatively large (magnitude 5.9) earthquake and the following magnitude 5.4 earthquake occurred near the plate boundary on November 25, just before the initiation of the tilt change. The seismicity in this area was usually low, and thus these earthquakes may relate to a possible SSE.

The Kishu observatory have recorded tilt changes since 1947, soon after the 1946 Nankai earthquake. Therefore, further detection of possible SSEs in the latter half of the 20th century will reveal how SSEs behave after large earthquakes.

Acknowledgments:

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We used tilt records at Kishu observatory operated and preserved by Disaster Prevention Research Institute, Kyoto University.

Keywords: Slow slip events, Tiltmeters, Kii Peninsula

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The effect of the steady plate subduction in the case of southwest Japan

*Yuto Iwase[1], Takeo Ito[1]

1. Graduate School of Environmental Science, Nagoya University

The deformation of the subduction zone expresses the superposition of the elastic coupling and the steady plate subduction. In the former, the elastic coupling on the plate interface corresponds to stress accumulation for the next earthquake. Thus, the earthquake releases the accumulated stress on the plate interface due to the elastic coupling. The accumulated stress due to elastic coupling is not accumulating over the earthquake cycle. In the latter, the steady plate subduction expresses the creeping on the plate interface. Hence, the shear stress on the plate interface does not accumulate within the earthquake cycle. However, the steady plate subduction effect the long-term deformation over the earthquake cycle. In order to understand the process of the subduction zone, the steady plate subduction is essential not only in seismology but also in geomorphology and geology.

In order to evaluate and understand the effect of steady plate subduction, we introduce a three-dimensional finite element (FE) method. Our target area is southwest Japan. We make a FE model that the size of a model region is 1460km×1400km×700km, where southwestern and northeastern corners of the FE model are corresponding to Amami Island and Tohoku region, respectively. The FE model considers the topography, the three-dimensional shape of the Philippine Sea plate and the complex underground structure that the Philippine Sea plate is subducting in the asthenosphere. The FE model consists of four blocks, such as the Philippine Sea plate, oceanic mantle, continental mantle, and crust. The material of mantle assumes a viscoelastic medium. The crust and the Philippine Sea plate assume an elastic medium. To realize the subducting Philippine sea plate, we set up the boundary condition. The kinematic expression of the Philippine Sea plate is the relative plate motion along the plate interfaces, which are both upper and bottom surfaces of the Philippine Sea plate. In this study, the relative plate motion at each point is expressed by the Euler pole.

As a result, the simulated long-term vertical deformation correlates with topography. The feature of large scale topography, such as the Seto Inland Sea, Kii mountain, Hyuganada and so on, are well reproduced. For the shear stress on the plate interface, The depth-dependent variation is available. There is small shear stress on the plate interface at deeper than Moho depth because of shear stress relaxed by a viscoelastic medium. At shallower than the Moho depth, although the shear stress is available, the direction of shear stress is different from the direction of the Philippine Sea plate because the three-dimensional shape of the Philippine sea plate produces the shear stress on the plate interface. For normal stress on the plate interface, the normal stress on the plate interface is more significant than shear stress. The normal stress produces long-term vertical deformation and tectonic stress distribution. Hence, the tectonic stress around subduction zone produced by dominantly normal stress. The normal stress on the plate interface does not relate with the curvature of the plate interface but is due to the curvature changing rate.

Keywords: steady plate subduction, southwest Japan, tectonic stress, three-dimensional finite element method (FEM)

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Development of Mechanical Coupling Model on Subducting Plate Interfaces

*Hiroshi Kimura[1], Takeo Ito[1], Keiichi Tadokoro[1], Ryohei Sasajima[2]

1. Department of Earth and Planetary Sciences, Nagoya University, 2. Research Center For Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University

Introduction

Interplate earthquakes occur at regions where the interplate strain has been accumulated by plate convergence. To evaluate the interplate seismic potential, many previous studies have tried to estimate the spatial distribution of interplate "coupling" [e.g., Loveless and Meade (2010); Yokota et al. (2016); Nishimura et al. (2018); Kimura et al. (in prep.)]. In their models, "coupling" is defined as the ratio between slip deficit rate and convergence rate, based on the kinematic concept. However, the actual situation of plate interface should be treated as mechanical "locking" (sometimes called as asperities) or "creeping". It is considered that the seismic ruptures at asperities can generate the strong-motion that gives constructions serious damages. Thus, it is essential to comprehend the spatial distribution of the mechanical "locking" region on the plate interface. We then introduce the two kinds of back-slips to develop the mechanical coupling model on the basis of the geodetic observation data. Using this model, we test several scenarios of mechanical coupling distributions along the Nankai Trough for forward simulation.

Modeling of Mechanical Coupling

The mechanical coupling model we developed in this study is similar to the "pinned asperities" model presented by Bürgmann et al. (2005). We consider two kinds of back-slip on the plate interface: active back-slip and passive back-slip. The first one is applied on the mechanical coupling region, that is the mechanically locked region to the plate interface between subducting and overriding plate. We calculate the active back-slip rate from the relative block motion rate based on the Euler vectors of each block. The second one is the slip around the mechanical coupling region generated to completely relieve the along-dip and along-strike shear strain due to the active back-slip. We model the relationship between shear strain concentration $\boldsymbol{\varepsilon}$ and passive back-slip rate $\boldsymbol{v}$ around the mechanical coupling region with a linear equation $\boldsymbol{\varepsilon} = G\boldsymbol{v}$, where G is the Green's function matrix. To estimate the passive back-slip, we first calculate the shear strain due to the given active back-slip on the mechanical coupling region. Then, we inverse the passive back-slip rate using the linear equation above. We repeat these two procedures until the shear strain concentration becomes zero. We call the region where the active or passive back-slip is observed as kinematic coupling region. The elastic component of crustal displacement at the surface can be calculated from the total back-slip on the kinematic coupling region.

Forward Simulation

We conduct the forward simulation using our mechanical coupling model for some scenarios of mechanical coupling distributions along the Nankai Trough. We divide the test region into 12 rigid blocks and calculate the active back-slip rate on mechanical coupling regions using the Euler vectors referring to Kimura et al. (in prep.). Figure 1 shows one example of (a) given mechanical coupling distribution and (b) spatial distribution of the simulated passive back-slip rate. Blue lines mean the edges of mechanical coupling regions. Because the relative block motion rate is about two times faster in the western region than that in the eastern region, the passive back-slip area is larger around the western mechanical coupling region, extending down to ~50 km in depths. In this presentation, we discuss for the other cases

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of mechanical distributions. In this study, we give the mechanical coupling distributions and Euler vectors for forward simulation. Because of this, the estimated passive back-slip rate depends on the given distribution, and we could not know other scenarios of mechanical coupling distributions. To resolve this problem, we will estimate the spatial distributions of mechanical coupling and Euler vectors simultaneously as a non-linear problem in future studies.

Keywords: Mechanical Coupling, Passive Back-slip, Strain Concentration, Crustal Deformation Observation Data, Plate Subduction Zone

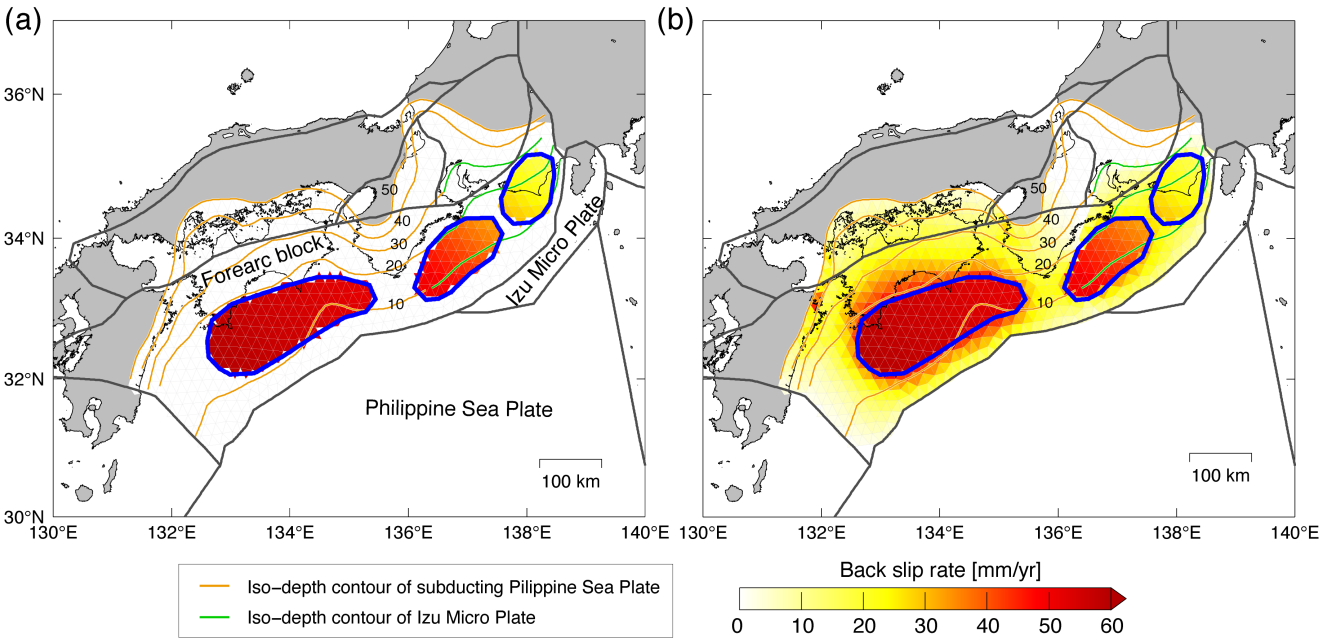

Figure 1: Map showing the spatial distribution of back-slip rate of (a) given active back-slip, and (b) calculated passive back-slip as well as given back-slip.

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Monitoring vertical deformation with optical lattice clock –an application of relativistic geodesy

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1. Earth and Planetary Science, The University of Tokyo, 2. Earthquake Research Institute, The University of Tokyo, 3. Mizusawa VLBI Observatory, National Astronomical Observatory of Japan

Crustal deformations due to earthquake and volcano activities have been detected by geodetic observation methods. The obtained deformations have been analyzed together with horizontal components and physical mechanisms (e.g., fault slip) to cause such deformations have been investigated. Representative methods to observe vertical deformation are leveling survey as a terrestrial method and the Global Navigation Satellite System (GNSS) as a space geodetic technique. The latter includes the Global Positioning System (GPS). Leveling has a long history (>100 years) and is still the most precise method to measure the height difference between relatively near two sites (e.g., <5 mm for 4 km). However, measurement errors increase with longer survey routes and it needs considerable time to complete the survey when the network is larger (about 2 km/day). GNSS, having a shorter history (<30 years), can measure the height difference over a long distance more precisely than levelling (plus-minus 1 cm for 24-hour average for \sim 100 km baseline). The spatial resolution is also better than levelling, thanks to the dense observation network such as GEONET in Japan. However, GNSS suffers from serious atmospheric noises. The precisions to detect vertical deformations in time scales shorter than 24 hours degrade (e.g., plus-minus 3 cm for 3-hour average) due to insufficient measurement time for canceling out the atmospheric noises. Seasonal time-scale crustal deformations are also hard to discriminate from the effects of atmospheric water vapor.Recently, precisions of atomic clocks have become better and better. In particular, optical lattice clock proposed in Japan (Katori 2002; 2017) achieved a relative precision of 5 x 10^-19 in three hours, which is approximately 3 orders of magnitude better than Cesium atomic clocks used to determine 1 second of International System of Units (SI). By the general relativity, the length of 1 second measured by an atomic clock changes according to the variation in the local gravitty potential (gravitational red shift). In general, the length of 1 second becomes shorter at higher altitude with smaller gravity potential energies. Fiber linked two optical lattice clocks can measure the relative potential difference between the two sites. The precision of 5 x 10^-19 corresponds to the height difference of 5 mm. Tectonic gravity potential changes in geodetic time scales are negligible in most cases since even an M-9 earthquake causes a geoid height change by only a few cm at maximum. This means that most part of the temporal variation in the measured gravity potential difference reflects the temporal change in height. The above-mentioned measurement precision and time by optical lattice clock is superior to GNSS, implying that optical lattice clock can replace GNSS as for monitoring of vertical deformation. Since November 2018, Japan Science and Technology (JST) has begun a new project regarding optical lattice clock, consisting of developers of optical lattice clock and geodesists. In this presentation, we will introduce this new project and the goal of the "relativistic geodesy" group. We discuss possible applications of optical lattice clock to crustal deformation monitoring.

Keywords: optical lattice clock, relativity theory, crustal deformation, gravity potential, atomic clock, relativistic geodesy

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Yuji Himematsu(Graduate School of Science, Hokkaido University), Atsushi Mukai(Faculty of Urban Management, Fukuyama City University)

Study of crustal deformation plays an extremely important role in the investigation of wide scale earth dynamics those are earthquake and volcanic activity, plate motion and so on. In our session, we discuss the study related to crustal deformation, such as development of observation instrument, observed crustal deformation, analysis method, and simulation study.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SSS16-07] Surface Deformation before and after the 2016 Kumamoto Earthquake Detected by SAR

*Manabu Hashimoto[1] (1.Disaster Prevention Research Institute, Kyoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SSS16-08] Co- and post-seismic crustal deformations associated with the 2016 Kumamoto earthquake sequence using ALOS-2/PALSAR-2 data

*Yuji Himematsu[1], Masato Furuya[1] (1.Graduate School of Science, Hokkaido University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SSS16-09] GNSS time series analysis of postseismic deformation induced by 2016 Kumamoto earthquake (M7.3)

*Satoshi Fuwa[1], Mako Ohzono[1] (1.Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SSS16-10] **The viscoelastic crustal response to the magma discharge/recharge in the upper crust: implications for the uplift of the Aira caldera before and after the 1914 eruption of the Sakurajima volcano**

*Tadashi Yamasaki[1], Freysteinn Sigmundsson[2], Masato Iguchi[3] (1.Geological Survey of Japan, AIST, 2.Nordic Volcanological Center, University of Iceland, 3.DPRI, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SSS16-11] Factors controlling annual changes in groundwater migration in the fault fracture zone of Manpukuji fault

*Atsushi Mukai[1], Shigeaki Otsuka[2], Yoichi Fukuda[3] (1.Faculty of Urban Management, Fukuyama City University, 2.Kobe Gakuin University, 3.Graduate School of Science, Kyoto Univ.)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

Discussion

Surface Deformation before and after the 2016 Kumamoto Earthquake Detected by SAR

*Manabu Hashimoto[1]

1. Disaster Prevention Research Institute, Kyoto University

We analyzed SAR images acquired by ALOS-1/2 and Sentinel-1 before after the Kumamoto earthquake in 2016 and detected preseismic and postseismic surface deformation.

We applied time series analysis to ALOS-1 images during 2007 - 2011 with StaMPS. However, we could not detect significant deformation around the Futagawa-Hinagu faults and in the Kumamoto plain.

For the purpose of study of postseismic deformation, we collected ALOS-2 and Sentinel-1 images that were acquired from both descending and ascending orbits till the end of 2018, and analyzed them with Gamma(R) software. We detect at least 6 spots of increase of Line of sight (LOS) in and around the active fault traces in ALOS-2 descending interferograms. Three of them are located close to surface traces of the Futagawa-Hinagu faults or their extension. The maximum LOS change exceeds 10 cm till August 2018. This deformation is much larger than postseismic ddisplacements observed with GNSS after other inland earthquakes in Japan. Converting LOS changes into quasi-EW and vertical components, we found that westward movement is dominant on the SE side of the Futagawa-Hinagu faults.

We also notice a zone of LOS increase of 6 cm or more that extends NW-ward in the Kumamoto city from the junction of Futagawa and Hinagu faults. We observed coseismic subsidence in the same area in coseismic interferograms and there are several reports of small surface ruptures. Considering the location and timing, this off-fault LOS increase may be related to stress release by this event. The fifth one is in northern part of the Aso caldera, which also exceeds 6 cm. The last is found in the Kikuchi city, more than 10 km north of the Futagawa fault. This zone is extended in the direction of WNW-ESE along a channel.

Sentinel-1 interferograms also show similar distribution of displacements in spite of low coherence.

Changes in LOS increase across the surface fault traces are so sharp and nonsymmetrical. It may be difficult to explain all these deformations with not only afterslip on a couple of faults. This area is covered with thick pyroclastic flow and marine or non-marine deposits. Because there may be a weak correlation between the distribution of these deposits and postseismic deformation, subsurface heterogeneous structure may affect spatial distribution of postseismic deformation.

Keywords: ALOS-1/2, Kumamoto Earthquake, postseismic deformation, SAR, Sentinel-1, Surface deformation

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Co- and post-seismic crustal deformations associated with the 2016 Kumamoto earthquake sequence using ALOS-2/PALSAR-2 data

*Yuji Himematsu[1], Masato Furuya[1]

1. Graduate School of Science, Hokkaido University

The 2016 Kumamoto earthquake sequence started to occur at 21:26 on 14 April 2016 (JST: Japan Standard Time) with Mw 6.2 earthquake at the southwestern part of the Beppu-Shimabara graben, one of the tectonic lines across the central Kyushu island. It was followed by moment magnitude (Mw) 7.0 mainshock on 16 April at 01:25. Japan Meteorological Agency catalog reported that the mainshock focal mechanism was dominated by strike-slip components with north-south extensional axis. Geodetic measurements by Global Navigation Satellite System (GNSS) and satellite synthetic aperture radar revealed not only right-lateral displacement as the focal mechanism showed, but also greater than 1 m of subsidence at the northwest side of the Futagawa fault. In particular, PALSAR-2 pixel tracking data depicted phase discontinuities across the northeast-southwest direction. Some urgent field surveys were also conducted, and reported the locations and dislocation amounts of surface ruptures due to the earthquakes (e.g., Shirahama et al., 2016). We compare displacements along the surface rupture that were derived from the PALSAR-2 pixel tracking data and the previous field surveys. Measuring displacements along the surface ruptures in detail is important for evaluating rupture processes and propagation features along the faults during the earthquake event.

We also report the post-seismic deformations following the 2016 Kumamoto earthquake using PALSAR-2 data, and discuss the difference of spatial characteristic in the co- and post-seismic deformations. Although some papers have also reported post-seismic deformations observed by GNSS measurements and Sentinel-1 InSAR data for estimating viscoelastic structures beneath the central Kyushu island, near-fault post-seismic deformations are still poorly understood. We employed the conventional InSAR stacking for extracting long-lasting small deformations and mitigating artificial noise. We also performed the 2.5-dimensional analysis for depicting quasi-eastwest and quasi-vertical displacements using the stacked interferograms. To identify the small deformation signals, two independent quasi-displacement fields are generated. Although multiple aperture interferometry (MAI) allow us to detect along-track horizontal movements, we could not identify actual post-seismic deformation signals due to strong ionospheric artifact noises in most of MAI data.

Keywords: Synthetic Aperture Radar, 2016 Kumamoto Earthquake Sequence, Crustal Deformation, Surface Ruptures, SAR Interferometry, ALOS-2/PALSAR-2

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GNSS time series analysis of postseismic deformation induced by 2016 Kumamoto earthquake (M7.3)

*Satoshi Fuwa[1], Mako Ohzono[1]

1. Hokkaido University

In order to investigate the afterslip and the viscoelastic relaxation mechanisms induced by the 2016 Kumamoto earthquake (M7.3), which occurred on 16 April 2016 in Kyushu Island, Japan, we conducted times series analysis of GNSS data. Although there are several models for this postseismic deformation, they treat early postseismic period with only velocity or displacement data. Several time series analysis for other large earthquakes is also proposed, but there has been little consideration about whether it reflects their mechanisms. We use 48 sites around the focal area of daily coordinates (F3 solutions) provided by the Geospatial Information of Japan (GSI) for two years from the earthquake. Because most of the afterslip is thought to be finished during the first 0.25 years in postseismic period, we fitted logarithmic decay function assuming the afterslip to 90-days postseismic time series data using weighted nonlinear least squares method and estimated their time constants. Then, we re-fitted both of logarithmic decay function and exponential decay function, which assuming viscoelastic relaxation, together to whole two years postseismic time series fixing the time constant of logarithmic decay function. As a result of this time series analysis, each afterslip and viscoelastic time evolution are estimated at each GNSS site. Using the cumulative deformation field of logarithmic decay function, afterslip distribution is estimated. The afterslip is located around the coseismic fault, and major slip area is assumed complementary to the coseismic slip area. Cumulative viscoelastic deformation signal is also used for rheological parameter estimation. We set stratified rheological structure, which composed of upper elastic layer and lower Maxwell viscoelastic layer, and searched appropriate thickness of elastic layer and viscosity of the viscoelastic layer. As a result, we found the elastic thickness with 20 km and viscosity of viscoelastic layer with 1×10^{19} Pa s. These estimated values roughly correspond to the results of previous studies. There are several remaining issues, such as the dependency of fitting period of the logarithmic time decay function, and application for the complicated fault geometry and rheological structure for modeling. However, this time series analysis and estimation of each mechanism using those results are effective to the interpretation for the postseismic deformation after this earthquake.

Keywords: 2016 Kumamoto earthquake, postseismic deformation, time series analysis

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The viscoelastic crustal response to the magma discharge/recharge in the upper crust: implications for the uplift of the Aira caldera before and after the 1914 eruption of the Sakurajima volcano

*Tadashi Yamasaki[1], Freysteinn Sigmundsson[2], Masato Iguchi[3]

1. Geological Survey of Japan, AIST, 2. Nordic Volcanological Center, University of Iceland, 3. DPRI, Kyoto University

Volcano deformation has often been analysed in terms of crustal elasticity, where the temporal volume change of the deformation source is required to explain any transient behaviour of ground displacement. However, the response of viscoelastic crust, both to magma discharge and eventual subsequent recharge, is not negligible because the effective crustal viscosity is expected to be lowered by higher geothermal gradient at volcanoes. The present study, using a 3-D finite element model with a linear elastic layer underlain by a linear Maxwell viscoelastic layer with spatially uniform viscosity, examines the viscoelastic crustal response to both magma discharge and recharge into the upper crust. The model considers a sill-like magma chamber emplaced at the bottom of the elastic layer inflating at a constant rate, during which the magma discharge due to an eruption occurs instantaneously all at once. Numerical experiments have revealed that the viscoelasticity in response to magma discharge promotes surface uplift. The uplift depends on how long the pre-eruptive magma charge lasted, that is, how much viscoelastic relaxation in response to the magma charge occurred in pre-eruption period. If the relaxation was significant, the uplift due to viscoelastic relaxation is greater than that due to magma recharge earlier in post-eruption period. On the contrary, at later times, the uplift due to magma recharge exceeds the relaxation-derived one. However, since the viscoelastic response to magma recharge detracts the uplift, the post-eruptive magma volume is recovered before the surface elevation is recovered. This viscoelastic model behaviour is then adopted for the geodetic data in the Aira caldera, southern Kyushu, Japan, giving important constraints on the model parameters. A model with constant magma supply rate explains the observed exponential-like recovery of the surface elevation after the 1914 eruption if the following conditions are satisfied: (1) the effective crustal viscosity is ~5x10^18 Pa s, and (2) magma emplacement at a depth of ~10-15 km is initiated ~50 years before the eruption, with a constant supply rate of at least ~0.01-0.02 km^3/yr. The constrained model predicts that the accumulated volume of magma during the first 50 years in the post-eruption period is lower than that estimated by elastic model, but is on the contrary larger thereafter. In addition, the surface uplift immediately before the 1914 eruption is predicted to be ~3 times lower than that supposed in previous studies. Our results suggest that geodetic signals observed before and after the magma discharge due to an eruption need to be revisited with respect to the crustal viscoelasticity.

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Factors controlling annual changes in groundwater migration in the fault fracture zone of Manpukuji fault

*Atsushi Mukai[1], Shigeaki Otsuka[2], Yoichi Fukuda[3]

1. Faculty of Urban Management, Fukuyama City University, 2. Kobe Gakuin University, 3. Graduate School of Science, Kyoto Univ.

Rokko-Takao station in the southern area of Hyogo prefecture crosses Manpukuji fault, and the groundwater discharge can be observed all the time about the fault fracture zone. The groundwater discharge and pore pressure observed at the station usually contain annual changes which have the minimum value in spring and the maximum one in autumn. However, the scale of the annual changes depends on year. In 2017, we could not see any definite annual changes in the groundwater discharge and pore pressure. In this study, we investigated some factors controlling the annual changes in groundwater migration and report about the effects of regional crustal movements, precipitation and seismic motions on them.

We have been performing the continuous observation of groundwater migration nearby the fault fracture zone with the groundwater discharge meter and the pore pressure meters, as well as crustal movements with strainmeters, extensometers and water-tube tiltmeters. We calculated the tidal amplitudes and phases in the groundwater discharge and pore pressure by applying the tidal analysis program 'BAYTAP-G' to the observational data, and compared them with the theoretical ones obtained by 'GOTIC2'; the program for computation of oceanic tidal loading effect. The observed phases in major constituents O1 and M2 almost agreed with the theoretical ones for every observed groundwater migrations. This shows that the groundwater discharge and pore pressure changes at the station have similar response to tidal stress.

The groundwater discharge and pore pressure changes in 2017 showed just slight annual changes, the amplitudes of which were at least 10% of the annual averages, while the amplitudes of the annual changes were a few 10% or more of the annual averages in other years from 2015. When we investigated the observational data of groundwater discharge that started to be observed before 2000, the annual changes were diminished definitely in 2005 and 2012 as well. It was considered that the variations in the amplitudes of annual changes might be caused by regional crustal movements, precipitation, seismic motions and so on.

We calculated the dilatation changes as regional crustal movements by using GSI's GEONET data. The dilatation showed significant annual changes even in 2005, 2012 and 2017, so that the diminished annual changes were considered not to be caused by the regional crustal movements. Second, we investigated the effect of annual precipitation. The annual precipitation were unusually small just before 2005, 2012 and 2017, so that it seems that small precipitation might cause decreasing of groundwater and small annual changes in groundwater migrations. However, this idea does not agree with the observed result that the pore pressure had kept to be high level all through 2017.
Permeability in the fracture zone of Manpukuji fault was observed to be reduced over one year after 2011 Tohoku Earthquake (Mukai and Otsuka, 2014). Similar permeability changes occurred just after 2016 Kumamoto Earthquake and 2016 Central Tottori Earthquake as well (Mukai et al., 2017). The diminishment of annual changes in groundwater migrations were observed just after such large earthquakes. This might suggest that temporal decrease of permeability due to the large earthquakes

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prevented groundwater migration and propagation of pore pressure, and resulted in the small annual changes.

Keywords: fault fracture zone, groundwater migration, annual change

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[J] Oral | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | A03 TOKYO BAY MAKUHARI HALL

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University), Chairperson:Takao Tabei(Department of Global Environment and Disaster Prevention, Faculty of Science and Technology, Kochi University), Takeo Ito

Study of crustal deformation plays an extremely important role in the investigation of wide scale earth dynamics those are earthquake and volcanic activity, plate motion and so on. In our session, we discuss the study related to crustal deformation, such as development of observation instrument, observed crustal deformation, analysis method, and simulation study.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SSS16-12] Rapid uplift in SW Taiwan caused by fold growth

*Yoshiki Takei[1], Youichiro Takada[2] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2.Hokkaido University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SSS16-13] Construction of GNSS monitoring system in Nepal for the earthquake potential evaluation in the Himalayan Frontal Zone

*Takao Tabei[1], Mako Ohzono[2], Kazuki Koketsu[3], Hiroe Miyake[3], Rajendra Bhandari[4], Janak B. Chand[4], Bishow R. Silwal[4], Soma N. Sapkota[4] (1.Department of Global Environment and Disaster Prevention, Faculty of Science and Technology, Kochi University, 2.Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University, 3.Earthquake Researech Institute, University of Tokyo, 4.Department of Mines and Geology, Nepal)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SSS16-14] The kinematic model along the Sumatran fault using a new dense GNSS observation (AGNeSS+) in Banda Aceh

*Takeo Ito[1], Takao Tabei[2], Fumiaki Kimata[3], Makoto OKUBO[2], Tadashi Yamashina[2], Cecep Pratama[4], Didik Sugiyanto[5], Mukusin Umar[5], Nazli Ismail[5], Irwandi Nurdin[5] (1.Nagoya Univ, 2.Kochi Univ, 3.Tono Research Institute of Earthquake Science, 4.Gadjah Mada University, 5.Syiah Kuala University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SSS16-15] Mechanical modeling of interseismic deformation in the Central Andes: implications for back-arc shortening

*Shaoyang Li[1,2], Fuqiang Shi[3], Marcos Moreno[4], Jun'ichi Fukuda[1] (1.Earthquake Research Institute, University of Tokyo, Tokyo, Japan, 2.Department of Earth and Environmental Sciences, The University of Iowa, Iowa City, IA, USA, 3.Shaanxi Earthquake Agency, Xi’an, China, 4.Departamento de Geofísica, Facultad de Ciencias Físicas y Matemáticas, Universidad de Concepción, Concepción, Chile)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SSS16-16] Inferring regional stress field based on SAR analysis and dynamic simulation of the 2018 Palu earthquake

*Takafumi Yokota[1], Ryosuke Ando[1], Yosuke Aoki[2] (1.Graduate School of Science, University of Tokyo , 2.Earthquake Research Institute, University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

Discussion

Rapid uplift in SW Taiwan caused by fold growth

*Yoshiki Takei[1], Youichiro Takada[2]

1. Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2. Hokkaido University

The Taiwan orogeny is result of the continental collision between the Luzon arc on the Philippine Sea plate and the Eurasian continental margin. GNSS velocity field indicates rapid and on-going east-west compression (e.g., Yu et al., 1997; Tsai et al., 2015). Due to such background compression, very rapid uplift up to 37 mm/yr has been aseismically proceeding in the southwestern part of Taiwan, which is detected by levelling and InSAR measurements (Ching et al., 2016; Tsukahara and Takada, 2018). Tsukahara and Takada (2018) showed that such rapid uplift cannot be explained solely by fault motion, and they concluded that a fold growth would contribute to the uplift motion as suggested by Ching et al. (2016). Actually, mud diapirs are widely distributed from South China Sea to the coastal area of Southwest Taiwan, and some of those are observed as mud volcanoes on land (e.g., Lin et al., 2009; Hsu et al., 2013; Doo et al., 2015). From physical point of view, mud diapirism can be regarded as a fold growth with buoyancy under strong horizontal compression. There is no previous study, however, that quantitatively estimates the possibility of fold growth in SW Taiwan. In this study, we quantitatively examined the fold growth rate in SW Taiwan on the basis of continuum mechanics. First, we modeled the earth’ s crust as non-linear viscous fluid following power-law creep. Next, considering that the background stress is much larger than the stress perturbation caused by the fold growth, we linearized the governing equations and analytically calculated the fold growth rate following the conventional method (Smith, 1977; Fletcher and Hallett, 1983). So far, this approach has been applied to foldings periodic in space, while the folds in SW Taiwan (on land) are not periodic but rather isolated. Following Bassi and Bonnin (1988) formulation, therefore, we assumed a Gaussian shaped fold at initial stage, and calculated its growth rate under various conditions. The medium consists of a substratum (mud) and a brittle surface layer. The power exponent is set as one for the substratum (Newtonian) and a thousand for the surface layer. In addition, we considered surface erosion and sedimentation that modify the effect of gravity as pointed out by Martinod and Molnar (1995).

The result of calculation shows that the Gaussian shaped perturbation can grow up for a certain combination of model parameters consistent with observations. Also, we found that surface erosion and sedimentation prompt the fold growth. The surface uplift and subsidence rates associated with the Gaussian shaped fold growth are roughly consistent with levelling and InSAR measurements. Among all, the subsidence pattern is well explained by the folding, which could not be explained by the elastic dislocation model (Okada, 1992). On the other hand, the largest uplift rate in the numerical simulation is about 10 mm/yr smaller than the ones given by InSAR and levelling surveys, which indicates that large displacement gradient in the observed result was not well reproduced by the simulation. The actual folding in SW Taiwan might associate brittle failures as well as viscous deformation. We will combine both fault motion and fold growth to explain the mechanisms of rapid aseismic deformation in SW Taiwan in the future.

Keywords: Aseismic crustal deformation, Fold growth, Taiwan

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Construction of GNSS monitoring system in Nepal for the earthquake potential evaluation in the Himalayan Frontal Zone

*Takao Tabei[1], Mako Ohzono[2], Kazuki Koketsu[3], Hiroe Miyake[3], Rajendra Bhandari[4], Janak B. Chand[4], Bishow R. Silwal[4], Soma N. Sapkota[4]

1. Department of Global Environment and Disaster Prevention, Faculty of Science and Technology, Kochi University, 2. Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University, 3. Earthquake Researech Institute, University of Tokyo, 4. Department of Mines and Geology, Nepal

We have deployed 10 continuous GNSS stations in central Nepal since 2016 under the SATREPS project of “Integrated Research on Great Earthquakes and Disaster Mitigation in Nepal Himalaya (NERDiM)” (2016-2021). The main purpose of the GNSS observation is to monitor ongoing crustal deformation for estimating earthquake generation potential in the Indian-Eurasian plate boundary zone. We focus especially on the crustal activity of the “Central Seismic Gap” located just west of the source region of the 2015 Gorkha earthquake (Mw 7.8), where no destructive event has been recorded since 1505. Prior to our project there were about 50 continuous GPS stations distributed over the whole of Nepal, most of which were constructed and maintained by universities and institutions in USA and France. We determined station deployment so as to reinforce such pre-existing networks. One-second and 30-second interval data collected at each station are automatically transmitted on a semi-daily basis to a data server at Kathmandu via domestic cell phone network. In addition, we have already introduced a high-performance machine that has the ability of automated GNSS data processing and archiving. Soon we will start daily baseline processing using GNSS data from the SATREPS NERDiM stations and also from the pre-existing domestic and international networks.

In paralle to the station construction, we collect all available GNSS data in Nepal and process them using PPP-AR method of GIPSY/OASIS II ver.6.4. Total number of stations is less than 10 as of 2004 and gradually increased year by year. Since the 2015 Gorkha earthquake, many stations have been added in and around the Kathmandu Valley. However, the number of stations where stable data collection is still ongoing may be less than 30. The result shows that roughly N-S contraction of about 0.1 ppm/yr is significant over the whole of the country, implying that about half of the relative Indian-Eurasian plate motion (36-37 mm/yr) is taken up in crustal shortening of the Himalayan frontal zone due to strong coupling on the plate boundary. Occurrence of the 2015 Gorkha earthquake disturbs deformation field in the source region in central Nepal but does not seem to affect further west. It means that large amount of strain has remained unreleased in “Central Seismic Gap”. We need to cope with high potential of earthquake generation in this region in the near future. New SATREPS NERDiM GNSS stations will contribute to enhance spatio-temporal resolution of the deformation field in the region concerned.

Keywords: Nepal, Earthquake, GNSS

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The kinematic model along the Sumatran fault using a new dense GNSS observation (AGNeSS+) in Banda Aceh

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1. Nagoya Univ, 2. Kochi Univ, 3. Tono Research Institute of Earthquake Science, 4. Gadjah Mada University, 5. Syiah Kuala University

The 2004 Sumatra-Andaman earthquake (Mw 9.2) has occurred along the Sunda trench. In Banda Aceh district, evaluation of the earthquake generation potential along the Sumatran fault is highly urgent because of a large fault slip rate, the lack of major earthquakes for more than 100 years and recent Coulomb stress increase on the fault due to the 2004 event. After the 2004 event, we have deployed the Aceh GNSS Network for the Sumatran fault System (AGNeSS), which consists of 24 GNSS sites. AGNeSS have releveled the along-strike variations of elastic coupling and creeping along the Sumatran fault system (Ito et al.,2012). Recently, seismic activity is increasing around the Seulimeum fault. So, we try to evaluate the earthquake potential around the Seulimeum fault.

However, AGNeSS have already passed a decade since developed, and the site condition of GNSS sites is disintegrating. So, we extend AGNeSS, which consists of new dense 25 GNSS site (we call the AGNeSS+). We developed the new GNSS site in 2016. The AGNeSS+ aims to evaluate the seismic potential along the Seulimeum fault, where is close to urban of Banda Aceh province. The new dense GNSS site has two profiles crossing the Seulimeum fault. The length and the average interval of the profile are about 30km and about 3km, respectively. Also, an interval of GNSS site near the Seulimeum fault is shorter.

In this study, we show the first result of AGNeSS+, and a block motion model around the Banda Aceh area base on AGNeSS+. We developed the block motion model based on geological information. The Banda Aceh city locates between two fault segments, which is Aceh and Seulimeum segments. The block motion model considers these block boundary. In this presentation, we show the first results of slip deficit along Seulimeum segments and kinematic block motion.

Keywords: GNSS, Banda Aceh, Block motion model

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Mechanical modeling of interseismic deformation in the Central Andes: implications for back-arc shortening

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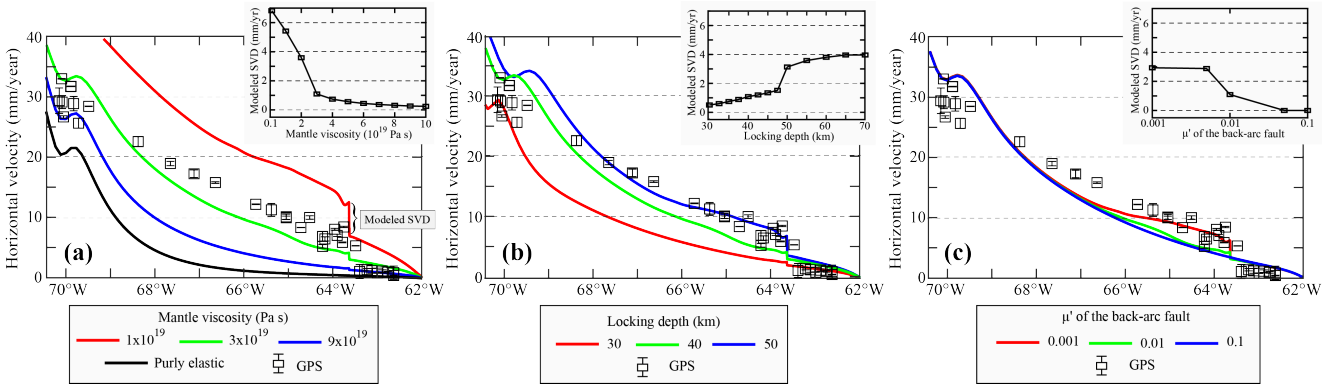
Coupling in the plate interface is considered the primary mechanical process transferring tectonic forces into interseismic deformation at subduction zones. Given that interseismic deformation affects the whole volume of the margin, the spreading of the deformation field across the continental plate not only depends on the pure-plate coupling deformation but is also affected by the rheological properties and active continental faulting. Here, we use numerical mechanical models, including viscoelastic mantle wedge and frictional back-arc fault, to investigate the interseismic GPS-derived velocity field in both horizontal and vertical directions in the Central Andes. In this region, GPS observations show a slow decrease of velocities over a significantly far-reaching area from the trench, with a sharp localized shortening gradient across a major back-arc fault at the trench distance > 800 km. These signals cannot be explained only by modeling plate locking and back-arc shortening. We first implement a grid-searching method to test the contribution and interaction of subduction locking and viscous mantle flow in the velocity field. Our simulation results show that these two processes produce similar horizontal deformation patterns, while the vertical deformation is particularly sensitive to the locking depth. We further perform mechanical viscoelastic models with a frictional back-arc fault and examine the effects of subduction locking, viscous mantle flow, and frictional strength of the back-arc fault on the activation of the back-arc fault (attached Figure). We find that the back-arc fault should be remarkably weak and is active only under considerable viscous mantle flow to reproduce the observed sharp localized shortening across the back-arc fault. Our results, therefore, suggest that the preexisting weakness of the crust plays an important role on the distribution of interseismic deformation and shortening the continental crust, highlighting a generic feedback between long-term mantle structure and present-day deformation.

Keywords: Interseismic deformation, GPS velocities, Back-arc shortening, Viscoelastic mantle relaxation, Central Andes



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Inferring regional stress field based on SAR analysis and dynamic simulation of the 2018 Palu earthquake

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The 2018 Palu, Indonesia, earthquake occurred along the Palu-Koro fault in the Sulawesi Island on 28th September. The Palu-Koro fault defines the boundary of the microplates, North Sula block and Makassar block. The information of the stress field around the Palu-Koro fault is necessary to understand the complicated tectonic system consisting of several micro-plates nearby Sulawesi Island as well as the basic mechanism underlying this earthquake event. Little, however, has been reported on the stress field probably due to relatively small seismic activity of this area. This study aims to estimate the stress field around the Palu-Koro fault based on the observed surface displacement and the fault slip pattern of 2018 Palu earthquake.

First, we compared SAR images taken before and after the earthquake by the pixel offset method to obtain the data of the surface displacement. The overall left-lateral displacement was observed with local variations in the geometry of the surface offsets. Then, we constructed the model of the Palu-Koro fault based on the surface displacement data and the previously-obtained geomorphological data. Finally, we simulate the surface displacement caused by dynamic rupture of the model of the Palu-Koro fault under given stressing conditions, and compare the result with the observation to infer the causative regional stress field.

The simulation is FDP-BIEM(fast domain partitioning - boundary integral equation method) [1]. The numerical cost of the original BIEM is in proportion to the cube of the total time steps. In contrast, that of FDP-BIEMis in proportion to the square of the total time steps. The simulation was performed on the physical assumption that one of the axes of principal stress is vertical, that the vertical principal stress equals to lithostatic pressure, and that the initial principal stress ratios are constant spatially. There are 3 free parameters. One is the azimuth of the axis of the maximum horizontal principal stress, and the others are the principal stress ratios.

This study constrains the azimuth of the axis of the maximum horizontal principal stress is within a certain range of about 25 degrees by considering the condition necessarily to explain the overall fault ruptures exhibiting left-laterally. If the azimuths of the horizontal principal stress axes are determined by independent observation such as the stress tensor inversions using focal mechanism solutions, this technique can also estimate principal stress ratios. More detailed modeling of the dynamic rupture process may also constrain the stress state around this fault zone.

[1]R. Ando, “On Applications of Fast Domain Partitioning Method to Earthquake Simulations with Spatiotemporal Boundary Integral Equation Method,” Mathematical Analysis of Continuum Mechanics and Industrial Applications II, Springer Nature Singapore Pte Ltd., 2018

Keywords: the 2018 Palu earthquake, dynamic rupture simulation, stress field

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[J] Poster | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_14

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University)

Study of crustal deformation plays an extremely important role in the investigation of wide scale earth dynamics those are earthquake and volcanic activity, plate motion and so on. In our session, we discuss the study related to crustal deformation, such as development of observation instrument, observed crustal deformation, analysis method, and simulation study.

[SSS16-P01] Earthquake Potential in Central Costa Rica based on Geodetic Observations

*Luis Alejandro Carvajal Soto[1], Takeo Ito[1], Hiroshi Kimura[1], Marino Protti Quesada[2] (1.Nagoya University, Earthquake and Volcano Research Center, 2.Observatorio Vulcanológico y Sismológico de Costa Rica, Universidad Nacional)

[SSS16-P02] Crustal deformation along the Liupanshan fault zone derived from GPS

*Weitao Chen[1,2], Weijun Gan[2], Genru Xiao[3], Shiming Liang[2] (1.Development Research Center, China Earthquake Administration, 2.Institute of Geology, China Earthquake Administration, 3.East China University of Technology)

[SSS16-P03] Convergence boundary and velocity between Amur and Okhotsk plates in northern Hokkaido inferred by GNSS velocity data

*Chihiro Ito[1], Hiroaki Takahashi[2], Mako Ohzono[2] (1.Graduate School of Science, Hokkaido University, 2.Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University)

[SSS16-P04] Vertical deformation and repeating earthquakes in southeastern Hokkaido in the last 100 years

*Hiroaki Kobayashi[1,2], Kazuki Koketsu[1], Hiroe Miyake[1] (1.Earthquake Research Institute, The University of Tokyo, 2.Now at Kobori Research Complex. Inc.)

[SSS16-P05] Simple estimation of interplate coupling in the Kushiro-oki and the Nemuro-oki regions, eastern Hokkaido in Japan from onshore GNSS data

*Hiroki Aota[1], Mako Ohzono[2], Fumiaki Tomita[3], Hiroaki Takahashi[2] (1.Department of Earth and Planetary Sciences, School of Science, Hokkaido University. , 2.ISV, Faculty of Science, Hokkaido University, 3.Graduate School of Science, Hokkaido University)

[SSS16-P06] Estimation of the early afterslip location of the 2011 Tohoku-Oki earthquake using onshore GNSS and offshore pressure data

*Putra Maulida[1], Yusaku Ohta[1], Ryota Hino[1] (1.Graduate School of Science, Tohoku University)

[SSS16-P07] Heterogeneous rheology structure estimated by the postseismic deformation following the 2011 Tohoku-Oki earthquake (M_w9.0)

*Yoshiaki Ito[1,2], Satoshi Miura[2], Jun Muto[2], Yusaku Ohta[2], Takeshi Iinuma[3], James Daniel Paul Moore[4] (1.Mitsubishi Space Software Co., Ltd., 2.Graduate School of Science, Tohoku University, 3.Japan Agency for Marine-Earth Science and Technology, 4.Nanyang Technological University)

[SSS16-P08] Contribution of linear and non-linear viscoelastic relaxation as postseismic deformation following an earthquake

*Hiroyuki Hoshino[1], SHINICHI MIYAZAKI[2,1], Kazuro Hirahara[2] (1.Graduate school of science, Kyoto University, 2.Institute of Education, Research and Regional Cooperation for crisis Management Shikoku, Kagawa University)

[SSS16-P09] Estimation of fault parameter with maximum ΔCFS based on GNSS data

*Shuntaro Fukaya[1], Mako Ohzono[2] (1.School of Science, Hokkaido University, 2.ISV, Faculty of Science Hokkaido University)

[SSS16-P10] Coseismic deformation of the 2018 Lombok earthquake, Indonesia, revealed through InSAR measurements

*ERLAN SUMANJAYA[1], MASATO FURUYA[1] (1.Hokkaido University)

[SSS16-P11] Recent crustal deformations around Mt. Azuma revealed by InSAR time-series analysis

*Hiroshi Munekane[1], Tomokazu Kobayashi[1] (1.GSI of Japan)

[SSS16-P12] The Fault model of the 2017 earthquake (M5.6) in the Eastern flank of Mt. Ontake estimated from precise leveling survey data

*Masayuki Murase[1], Naoka Kitazume[1], Yoshiko Yamanaka[2], Takeshi Matsushima[3], Fumiaki Kimata[7], Hitoshi Yamashita Mori[1], Takamasa Hase[1], Yang Li[1], Kazuki Ofuchi[1], Takahiro Kunitomo[2], Yuta Maeda[2], Shinichiro Horikawa[2], Takashi OKUDA[2], Kenjiro Matsuhiro[2], Kazushi Tanoue[2], Kazunari Uchida[3], Yoshiko Teguri[3], Rintaro Miyamachi[3], Kaori Morita[3], Yoshikawa Shin[4], Hiroyuki Inoue[4], Isao Kageyama[5], Syuichi Hosokawa[5], Takahiro Yanada[5], Rinah Tanaka[1], Ryosuke Doke[6] (1.Department of Earth and Environmental Sciences, College of Humanities and Sciences, NIHON University, 2.Graduate School of Environmental Studies, Nagoya University, 3.Graduate School of Sciences, Kyushu University, 4.Graduate School of Sciences, Kyoto University, 5.Japan Meteorological Agency, 6.Hot Springs Research Institute of Kanagawa Prefecture, 7.Tono Research Institute of Earthquake Science)

[SSS16-P13] Detection ability of Crustal deformation by Slow Slip Events along the Nankai Trough subduction zone

*Kazuki Miyaoka[1], Reiko Kai[1], Takeshi Kimura[2], Takahiro Tsuyuki[3] (1.Japan Meteorological Agency, 2.National Research Institute for Earth Science and Disaster Resilience, 3.Meteorological Research Institute)

[SSS16-P14] An investigation into slow-slip detection capability of the Tokai Strainmenter Network

*Kazuyoshi Nanjo[1] (1.University of Shizuoka)

[SSS16-P15] A Study on Trend Component Estimation Method of Strain Time Series Data Using State Space Model

*Takahiro Tsuyuki[1] (1.Meteorological Research Institute)

[SSS16-P16] Rainfall correction of strainmeter data in consideration of the flow from the upper reaches (2)

Kazuhiro Kimura[1], *Akio Kobayashi[2] (1.Japan Meteorological Agency, 2.Meteorological Research Institute, Japan Meteorological Agency)

[SSS16-P17] Long-term slow slip event beneath the Shima Peninsula from 2017 to 2018

*Akio Kobayashi[1], Takahiro Tsuyuki[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

[SSS16-P18] non- fault slip source components of long-term SSE and the relation to interseismic process preparing for large earthquake generation

*Noa Mitsui[1], Takeo Ito[2] (1.Tono Research Institute of Earthquake Science, 2.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University)

[SSS16-P19] **Restart of the long-term slow slip events along the Nankai trough after the 2016 Kumamoto earthquake, Japan**

*Shinzaburo Ozawa[1], Hiroshi Yarai[1] (1.Geographical Survey Institute of Japan)

[SSS16-P20] Crustal deformation in the San-in Shear Zone as observed by a dense GNSS network

*Angela Meneses-Gutierrez[1], Takuya NISHIMURA[1] (1.Disaster Prevention Research Institute, Kyoto University)

[SSS16-P21] Two-dimensional Fourier series representation of surface deformation: Different scales of crustal deformation

*Akemi Noda[1], Tatsuhiko Saito[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[SSS16-P22] GNSS observation around the shear zone in southern Kyushu (The third report)

*Tsuyoshi Watanabe[1], Atsushi Saiga[2], Koichi Asamori[1], Hiroki Ogawa[1], Akiomi Shimada[1], Koji Umeda[3] (1.JAEA, Tono Geoscience Center, 2.JAEA, Horonobe Underground Research Center, 3.Hirosaki University)

[SSS16-P23] Post-seismic deformation of 2016 Kumamoto Earthquake by continuous GNSS network (3)

*Shigeru Nakao[1], Takeshi Matsushima[2], Takao Tabei[3], Makoto OKUBO[3], Tadashi Yamashina[4], Takahiro Ohkura[5], Takuya NISHIMURA[7,6], Takuo Shibutani[6], Masahiro Teraishi[6], Takeo Ito[7], Takeshi Sagiya[8], Kenjiro Matsuhiro[7], Teruyuki Kato[9], Jun'ichi Fukuda[9], Atsushi Watanabe[9], Satoshi Miura[10], Yusaku Ohta[10], Tomotsugu Demachi[10], Hiroaki Takahashi[11], Mako Ohzono[11], Teruhiro Yamaguchi[11], Kazumi Okada[11] (1.Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University, 2.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 3.Department of Global Environment and Disaster Prevenction, Faculty of Science and Technology, Kochi University,, 4.Kochi Earthquake Observatory, Faculty of Science and Technology ,Kochi University, 5.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 6.Disaster Prevention Research Institute, Kyoto University, 7.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University, 8.Disaster Mitigation Research Center, Nagoya University, 9.Earthquake Research Institute, University of Tokyo, 10.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University,, 11.Institute of Seismology and Valcanology, Graduate School of Science, Hokkaido University)

Earthquake Potential in Central Costa Rica based on Geodetic Observations

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The Central Costa Rica Deformed Belt is the extension of the North Panama Deformed Belt, a diffuse predominant northwest dextral-strike and conjugated northeast sinistral-strike faulting area, that represents the western border of the Panama Microplate. This diffuse boundary crosses Central Costa Rica from the Caribbean Coast, including the active Cordillera Volcanica Central, the Metropolitan Area (most dense population area in Costa Rica) and the Central Pacific coastline to intersects the Meso American Trench along the subduction of the Cocos Plate.

We integrated interseismic geodetic data with seismicity records and inland faulting traces in other to evaluate earthquake potential in 4 kinematic models with different spatial geometries of the tectonic configuration around Central Costa Rica. Crustal deformation in Central Costa Rica and surroundings is modeled as result: i.kinematic effects of rigid block motions, ii.elastic deformation due to the interaction on subduction and inland tectonic interfaces and iii.internal strain of each tectonic block. We adopted the Markov Chain –Monte Carlo method in order to approximate the solution for each kinematic model.

Our estimation of the velocity field in Costa Rica suggests that the crustal deformation in Costa Rica is mainly arranged in three groups: 1). Northwestern Costa Rica is dominated by a northward deformation with rates up to 30 mm a^{-1}, rotating and decreasing up to 20 mm a^{-1} northwestward following the Central American Forearch. 2). Southeastern Costa Rica shows deformation to the North-east up 40 mm a^{-1} (opposite to northwestern Costa Rica). 3). Central Costa Rica is characterized by a diffuse deformation pattern oriented mainly to northward, with deformation rates up a half of those observed in northwestern and southeastern Costa Rica. According to the values of slip deficit in interfaces of each model and analysis of local seismicity, we provide results about the earthquake potential in Central Costa Rica, where it is possible to reach earthquakes higher than Mw. 6.5 in all models.

Keywords: Central Costa Rica, Earthquake potential Costa Rica, Crustal Deformation Costa Rica

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Crustal deformation along the Liupanshan fault zone derived from GPS

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The Liupanshan fault zone is located in North Central of North-South Seismic Belt, which is the boundary between the northeastern margin of the Tibetan Plateau and Ordos. This study collected 261 GPS stations distributed around the Liupanshan fault zone. 249 stations are belong to CMONOC and start to observe since 1999, 15 stations are constructed by this study and start to observe since 2013. GPS data are processed with the software GIPSY/OASIS (Version 6.0) from JPL, using the Precise Point Positioning (PPP) strategy and JPL products to obtain daily loosely constrained solutions. The result shows that the northern section of fault zone has a relatively weak left-lateral strike slip and 1.5mm/yr dip slip rate, but no significant difference motion is observed on both sides of the southern section. Furthermore, the maximum principal strain rates indicate that the deformation characteristic of the fault is extrusion, and the value gradually decreases from north to south.

Keywords: GPS, Crustal Deformation, Liupanshan Fault

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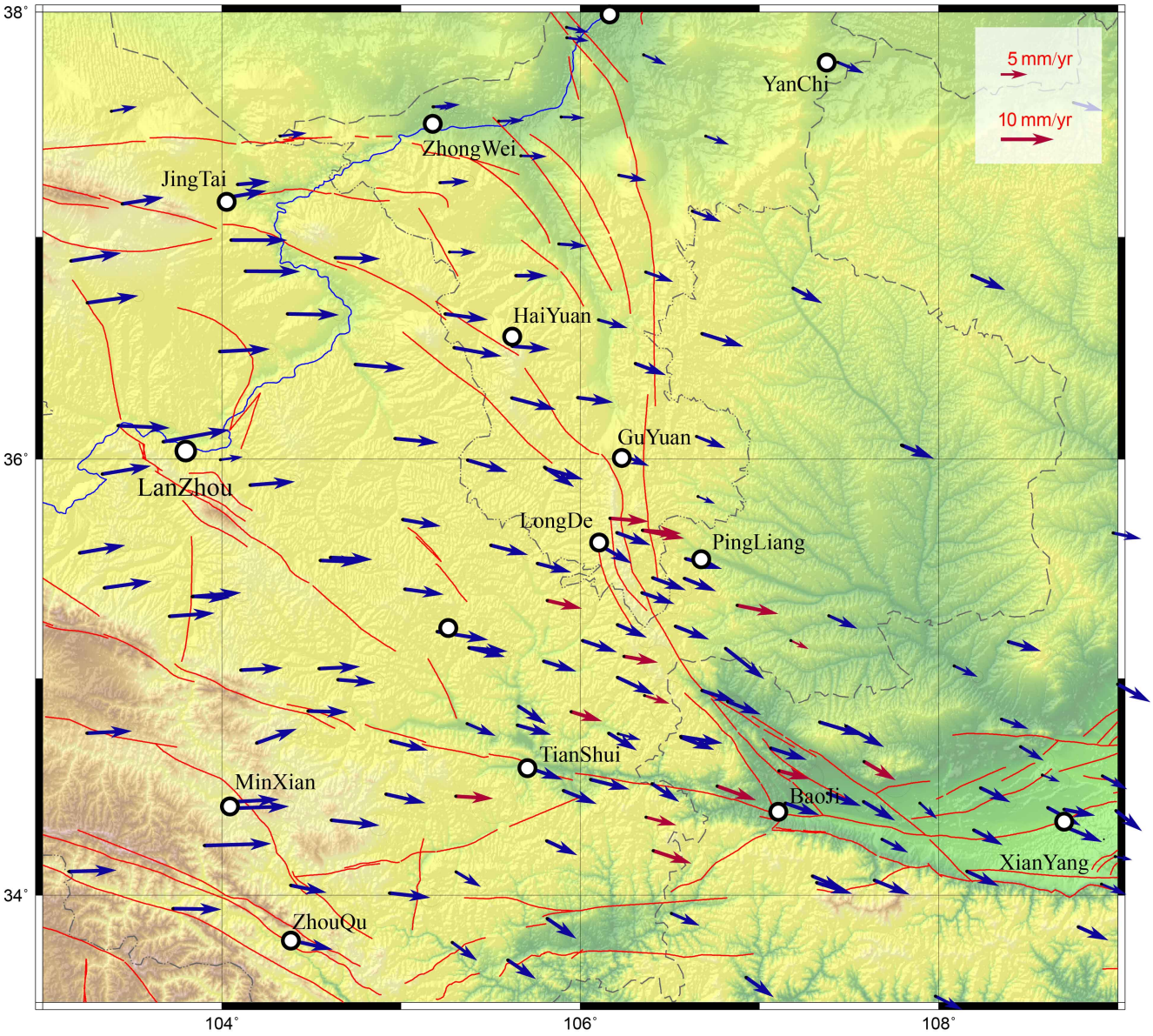

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Convergence boundary and velocity between Amur and Okhotsk plates in northern Hokkaido inferred by GNSS velocity data

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Tectonics of east Asia especially around Japan are complex. Earthquakes at the eastern margin of the Japan sea are due to interaction of plates, and some huge events occurred. However, there is absence of seismicity at west off northern Hokkaido; between focal regions of Shakotan-oki earthquake in 1940 (M7.0) and southwest off Sakhalin earthquake (M7.1). Sarobetsu active fault zone is located onshore of northern Hokkaido, the Japan Sea side, and pointed that it has potential of earth quake generation over M7.6 by the Headquarters for Earthquake Research Promotion. In northern Hokkaido, a boundary between Amur and Okhotsk plates has been assumed. Its geometry has been in debate, and there are many plate boundary models. In addition, distribution of seismic activity and geological structure indicate there is difference of the structure between west and east parts.

Several block models are constructed, and the boundary is estimated by using geodetic data in this region (e.g., Loveless and Meade, 2010), but comprehensive discussion considering geological structure, the Bouguer gravity anomaly and earthquake distribution is lacked. To verify the insistence that the boundary between Amur and Okhotsk plates exists onshore in northern Hokkaido, we estimate the location of the boundary, convergence velocity and elastic thickness applying a dislocation model for collision zone by Shimazaki and Zhao (2000) to represent velocity field observed by Global Navigation Satellite System (GNSS). Most of previous studies for northern Hokkaido fixed location of the boundary arbitrary. Therefore, we treated the boundary location as unknown parameters and estimate it in this study.

Estimated location of the collision boundary is in ENE-WSW direction and roughly consistent with boundary of seismicity, geological structure, and Bouguer gravity anomaly. Geological structures would behave as a kinematic boundary. Estimated thickness of elastic zone is 21.6-28.8 km. Indicator of seismic activity in vertical direction; D90’ s and Moho depth are 20-30 km and 30 km, respectively. In this model, determination accuracy of thickness is lower than the other parameters, however consistent with the discontinuous depth indicates that estimation of other parameters would show plausible value. Estimated velocity is 13.7-18.9 mm/yr, and these values are consistent with results by other studies that estimated velocity between some plates. The boundaries that estimated by discrete data, geology, seismology, and our result, roughly consistent with each other. Therefore, possibility that the boundary between Amur and Okhotsk plates is located onshore of northern Hokkaido became increasingly high.

Keywords: GNSS measurements, crustal deformation, collision zone, northern Hokkaido

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Vertical deformation and repeating earthquakes in southeastern Hokkaido in the last 100 years

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In the southernmost part of the Kuril subduction zone, six large to giant interplate earthquakes have occurred in the last 400 years. This includes the two M_w ~ 8 Tokachi-oki earthquakes that occurred in 1952 and 2003. In Hokkaido, instrumental seismic and geodetic observations began in the late 19th to early 20th centuries. Therefore, we are able to investigate more than a single M8 class earthquake cycle there using the observation data.
In this study, we investigated leveling data and repeating earthquakes in southeastern Hokkaido in the last 100 years. For the leveling data, we chose the survey route around Cape Erimo because the survey was conducted in 1952 and 1953 after the 1952 earthquake, the route has not changed since the first survey and is located near the coast, and there is likely no subsidence due to the pumping of underground water. We also estimated the crustal deformation due to medium-sized (M larger than or equal to 6.5) earthquakes since 1908 by simple uniform slip models. For some earthquakes, we estimated the focal mechanisms by analyzing the analog seismograms and the first motion polarity data.
For the investigation of the historical occurrences of repeating earthquakes, we chose two groups around Hokkaido whose average M_{JMA} is 5.4 from the catalogs of Uchida and Matsuzawa (2013) and Seismology and Volcanology Research Department of Meteorological Research Institute et al. (2014). Using the JMA catalog, we selected earthquakes occurring prior to 1993, whose epicentral distance from the known repeating earthquakes was less than 20 km and whose M_{JMA} was between 5.1 and 5.7. In addition, we checked a few earthquakes whose epicentral distances were less than 30 km. We used the the Headquarters for Earthquake Research Promotion data retrieval system to obtain copies of the analog seismograms and determined the repeating earthquakes by visual comparisons. We also estimated the aseismic slip rate around the groups.
The results of these investigations reveal that the afterslip of the 1952 earthquake may have continued until around 1980. Moreover, in the Tokachi-oki region, the state of the plate interface prior to the 1952 earthquake may be similar to that prior to the 2003 earthquake. Furthermore, the acceleration of aseismic slip around 1980 can be found in the west of Cape Erimo.

Keywords: Leveling data, repeating earthquake, analog seismogram, Tokachi-oki region

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Simple estimation of interplate coupling in the Kushiro-oki and the Nemuro-oki regions, eastern Hokkaido in Japan from onshore GNSS data

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It is important to understand interplate coupling conditions on plate interface to upcoming earthquake occurrence. The interplate coupling along the Kurile trench in the Kushiro–Nemuro-oki region eastern Hokkaido in Japan, have been discussed by many previous studies using onshore geodetic data (e.g., Hashimoto et al., 2009), and most of them estimated high coupling ratio in around the region during the interseismic period. A study of tsunami analysis points out the possibility of a great earthquake occurrence along the shallow part of this area in 17th century(Ioki and Tanioka 2016). Therefore, there is a possibility that a great earthquake will occur in the future. Under those background in this area, there is a plan to install two GNSS-Acoustic (GNSS-A) observation sites on the seafloor to understand the interplate coupling more precisely, especially for near the trench. As the preliminary research, we estimate interplate coupling ratio and its distribution around this region from onshore GNSS data (GEONET), and confirm the constrain limit of the result for sea area. We construct simple backslip model(Sanvage, 1983) in an elastic half-space(Okada, 1992), we calculated several synthetic profiles of the displacement rate due to the plate coupling assuming various coupling ratios and various ranges of the coupling zone, and we explored an optimal condition to explain the profile of the observed displacement rates. As a result, using the horizontal component data, coupling ratio, depth of the up-dip limit and of the down-dip limit of the coupling zone was calculated to be 1.0–1.1, 0–5 km and 50–55 km, respectively. In this result, coupling ratio was over 1.0. The reason of this high coupling ratio is probably caused by small plate convergence velocity (8.4 cm/yr)(Altami et al., 2016) we assumed in this study, and/or ignorance of viscoelastic effect in the asthenosphere. The estimated coupling zone is deeper than that of the previous studies(e.g., Hashimoto et al., 2009). This might be caused by our simple assumption of a uniform dip-angle of the plate interface fixed to 15 degrees. As for the actual geometry of the plate interface, the dip angle is increased with depth; thus, we should consider it for the next modeling. As previous studies(e.g., Hashimoto et al., 2009) suggested, it is difficult to constraint the interplate coupling condition of shallow part around the trench only from onshore geodetic data. Meanwhile, in order to find the appropriate GNSS-A installation areas, we explored locations sensitive to the fault parameters for the shallow coupling by comparing the above synthetic profiles of the placement rates. As a result,, we determined two points as candidates at 25 km and 40 km from the trench axis considering the detection limits of the observations, which correspond to the following the conditions: (1) a point demonstrating clear differences among the velocity profiles depending on special extent of the coupling area, and (2) a point demonstrating a large inclination of each profile. Since our estimation is simple due to the ignorance of the underground rheological structure and of the distilled plate geometry, it is necessary to update the modeling results by considering the above matters and other additional geophysical information, such as seismic activities in this region.

Keywords: Earthquake, Crustal deformation, Interplate coupling

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Estimation of the early afterslip location of the 2011 Tohoku-Oki earthquake using onshore GNSS and offshore pressure data

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Understanding of spatial and temporal development of the early afterslip just after the large earthquake is extremely important to characterize the frictional properties vicinity of an earthquake. Widely installed onshore geodetic data has been utilized to estimate the frictional properties along the plate interface (e.g. Miyazaki et al., 2004). One of the opportunity to study for early afterslip of the large event is 2011 Tohoku-Oki Earthquake. Dense continuous GNSS was installed nationwide, which had captured whole time period for this event successfully. Thus, we focus on the early afterslip of the 2011 Tohoku-Oki event in this study using both of onshore GNSS and offshore pressure data.

For the onshore GNSS data, we estimated the every 30 seconds kinematic time series until 18 hours after the mainshock. To enhance the signal-to-noise ratio of kinematic time series, we applied the principle component analysis (PCA) for kinematic PPP time series. We removed the lower contribution components from raw time series. For the offshore pressure data, we used the data-set by Hino et al. (2014). The raw OBP time series was sampled into 1 minute, after taking 1 minute average of raw data. Next, the resampled pressure data were de-tided, de-drifted and corrected by the ocean model to detect the seafloor deformation (Inazu et al, 2012). The time series of corrected OBP showed a strong signal of tsunami wave propagation. To clearly showed the tectonic deformation of the seafloor, we applied moving average of a window of (time with of windows) in length. The amount of displacement was estimated based on logarithmic functions fitted to the filtered pressure records.

To estimate the spatial and temporal development of early afterslip, we applied a conventional network inversion filter (NIF) (Segall and Matthews, 1997). We assumed an elastic half-space model (Okada, 1992) to calculate green functions of surface displacement due to slips on subfaults. We assumed local benchmark motions in unknown state vectors. To reduce the number of unknown parameters, we assumed pure reverse faulting. We omitted 10 minutes parts just after the mainshock from both onshore and offshore data because of the large disturbance caused by the seismic wave passage.

We estimated the early afterslip distribution using two different data sets for comparison. First one is the result from the onshore GNSS data only. Second one is the result both from the onshore GNSS and the offshore pressure data. Using only the onshore data, the estimated afterslip mainly concentrate on the deeper extension of the coseismic slip distribution. Spatial pattern of the estimated afterslip consistent with previous study (e.g. Munekane et al. 2012). In contrast, obtained early afterslip distribution completely difference when we included the offshore data. The estimated afterslip mainly concentrated in the shallower part of the subducting plate interface. Estimated moment release amount reached 2.37 x 10^{21} Nm (correspond to Mw 8.24) after the 18 hours from the mainshock. It clearly larger than the previous studies such as Munekane et al [2012]. It may be caused by the offshore pressure data. Just after the 2011 Tohoku-Oki event, all of the ocean bottom pressure time series indicate the clear subsidence signal. To explain this subsidence, afterslip cannot locate in the deeper part of the subducting plate interface because the afterslip in the deeper part generate the upward displacement in the ocean bottom pressure sites.

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We will discuss the more detail characteristic of the estimated early afterslip distribution. We also try to estimate the afterslip distribution using L1 regularization inversion (e.g. Evans et al., 2012) approach to illuminate the location of the afterslip just after the mainshock.

Keywords: Early afterslip, Ocean Bottom Pressure, GNSS, Network Inversion Filter

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Heterogeneous rheology structure estimated by the postseismic deformation following the 2011 Tohoku-Oki earthquake (M_w9.0)

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The 2011 Tohoku-Oki earthquake (M_w9.0) was the largest earthquake ever recorded in Japan and triggered substantial and long-lived postseismic deformation. We investigate the characteristics of the postseismic deformation based on the across-arc dense GNSS network running between Iwaki and Niigata cities (Ban-Etsu line) operated by the Geospatial Information Authority of Japan (GSI) and Tohoku University. Using the network, estimated the heterogeneous viscoelastic structure to reproduce the observed 5-year-displacements and their time series. It is revealed that both local subsidence during the first 2 years and gradient changes in all displacement components during latter 3 years occurred around the volcanic front (VF). To evaluate the time series of postseismic deformation, we normalized the horizontal scalar displacements by the total displacements in 5 years to define “relaxation rate.” Picking up the date when the relaxation rate reaches every 0.1 interval from 0 to 1, we obtain “relaxation rate profile (RRP).” The RRP shows that the relaxation rates are generally high and low in the fore-arc and back-arc regions, respectively, together with the relatively higher rate 350 to 400 km apart from the trench. We employed the integral method called Unicycle (Lambert and Barbot, 2016; Barbot et al., 2017) to conduct a three-dimensional modeling of the postseismic deformation considering the afterslip and viscoelastic relaxation. The former is governed by the rate-strengthening friction approximation (Barbot et al., 2009) and the latter is based on power-law Burgers model (Masuti et al., 2016). The viscoelastic parameters were optimized by means of a grid search with minimizing RMS (root mean square). The optimum viscoelastic structure has a low viscosity zone (LVZ) beneath VF and the “cold nose (CN)” region from the trench to around VF, and is consistent with the resistivity structure estimated by Uyeshima et al. (2016) and with the spatial extent of CN deduced by Freed et al. (2017). The model reproduced the overall characteristics of the displacement and the RRP, while the detailed characteristics such as flat pattern 350 to 400 km apart from the trench cannot be replicated. Varying the LVZ’s extent and viscosity, we obtained a better model with the LVZ at 25-55 km in depths to fit the observed characteristics, but more considerations are necessary. However, our best model for the Ban-Etsu line cannot be applicable to a northern across-arc profile, Naruko line of Muto et al. (2016), implying the along-arc heterogeneity of viscoelastic structure. Then, we examined the along-arc heterogeneous CN models, a better model with small extent of the CN in the northern area and the spot-like LVZ beneath the active volcanoes is estimated. The final model explains the observed displacements and also the areal strain distribution (Miura et al., 2014). This suggests the importance of considering not only across-arc but also along-arc heterogeneous viscoelastic structure to explain the observed postseismic deformation of the Tohoku-oki earthquake.

Keywords: postseismic deformation, Tohoku-oki earthquake

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Contribution of linear and non-linear viscoelastic relaxation as postseismic deformation following an earthquake

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Postseismic deformation following the 2011 Tohoku-oki earthquake has been observed at GPS and GPS/Acoustic stations. Previous studies have estimated the contribution of viscoelastic relaxation as the postseismic mechanism as well as afterslip. Those studies employed Maxwell rheology or Burgers rheology for asthenosphere. Some studies advocate non-linear rheology. However, it is still unclear which rheology is the most suitable to the real Earth.

Barbot and Fialko (2010) presented a theory that represent any types of postseismic processes given the constitutive equations. Viscoelastic relaxation, afterslip and poroelastic rebound were involved in the theory. This representation enables us to use both linear and non-linear viscoelastic rheology as postseismic viscoelastic relaxation. In this study, we developed a numerical code referencing this theory. The process of the calculation is following. (1) Coseismic displacements and stress changes are calculated based on Okada (1992). (2) In each time step, the field of moment density rate derived from the postseismic mechanisms is calculated analytically given the stress field. (3) Fields of velocity and strain rate are calculated from the moment density rates. (4) Fields of displacement and stress at the next time step are obtained by integrating velocities and stress rates with time, respectively.

In this presentation, we calculate postseismic deformation including viscoelastic relaxation, for a dip-slip and a strike-slip earthquakes. Results for different rheology models are compared to examine the suitable model to reproduce the characteristics of postseismic displacement data. We plan to compare calculated results with the observed postseismic GNSS data following earthquakes, such as the 2011 Tohoku-oki earthquake.

Keywords: rheology, postseismic deformation, viscoelastic relaxation

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Estimation of fault parameter with maximum ΔCFS based on GNSS data

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In order to estimate fault parameter (strike, dip and rake), which has the maximum ΔCFS (coulomb failure stress) at each area, we analyze horizontal GNSS data and compared the results with existing active faults. The ΔCFS is useful information to assess whether the fault tends to slip or not, based on stress redistribution induced by stress disturbances such kind of large earthquakes. Although the ΔCFS is calculated assuming source fault and its dislocation theory in general, Ueda and Takahashi (2005) and Nishimura (2018) propose an effectiveness of ΔCFS calculation from surface strain distribution observed by GNSS data. In this study, we apply this approach and search fault parameters that has the maximum ΔCFS at each area. For the test case, we calculated ΔCFS for an active fault, Yamagata-basin fault zone, using GEONET data before and after the 2011 Tohoku-oki earthquake. As a result, calculated stress field and estimated fault parameters before the earthquake well corresponds to the geometry of the actual active fault. From this test, we also found that this method calculates the ΔCFS with dip-dependency. This is due to the absence of vertical information in our method. Under the constraint of dip angle, we apply this method for Tohoku region using horizontal displacement data from September 2004 to September 2007, then we compared the result and active faults database. As a result, the region that shows high value of ΔCFSs and its fault parameters correspond to the region that evaluated S rank (category of high risk) and X rank (evaluation is difficult because of few data) faults announced by the Earthquake research committee. We also found high value of ΔCFS area even in areas without active faults. The source region of the 2008 Iwate-Miyagi inland earthquake is one of them. The estimated fault parameters with high ΔCFS also correspond to the fault mechanism of it. If the strain and stress estimated from horizontal GNSS data is caused by elastic accumulation on the fault, our method probably useful for future fault slip assessment on the current high ΔCFS fault at each area.

Keywords: ΔCFS, GNSS, active fault

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Coseismic deformation of the 2018 Lombok earthquake, Indonesia, revealed through InSAR measurements

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Interferometric Synthetic Aperture Radar (InSAR) is a space-based technique allowing to derive images of ground surface deformation. This method is based on repeated acquisitions by a Radar system onboard a satellite. We use Advanced Land Observing Satellite-2 (ALOS-2)/Phased Array-type L-band Synthetic Aperture Radar-2 (PALSAR-2) InSAR data sets from ascending stripmap mode and descending ScanSAR data. Meanwhile, we also use JAXA’ s AW3D DEM to correct for the topographic phase. These datasets allow us to more completely detect the deformation signal around the epicentral region caused by three Mw > 6 shallow earthquakes occurred in Lombok island, Indonesia. These events are of almost dominant thrust mechanism using GCMT solutions. The results show that the maximum amplitude of the line of sight (LOS) displacements are covering the mainshock of 35 cm in ascending and 30 cm in descending observations which is close to the epicenter of the earthquake. Both of which indicate that the surface was approaching toward the satellite. Because of ALOS-2 interferogram images are affected by ionospheric disturbances; therefore, we also perform ionospheric correction using split spectrum method (SSM), and the result shows that no signal of the ionosphere is detected there so that we can ignore the effect of the ionosphere. Meanwhile, to find slip distribution around the epicentral area, we plan to generate a fault source model using triangular dislocation element in an elastic halfspace.

Keywords: The 2018 Lombok earthquake , Coseismic deformation, InSAR

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Recent crustal deformations around Mt. Azuma revealed by InSAR time-series analysis

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Mt. Azuma is a complex volcano on the border of Fukushima/Yamagata pref., located approximately 200 km north of Tokyo. Increased volcanic tremors/earthquakes were observed in 2014 around Mt. Azuma that associate inflations around Mt. Issaikyo, one of the peak within the complex. Correspondingly, enhanced geothermal activities were observed around the O-ana crater between 2013 and 2015. These activities had ceased in 2016, but then in 2018, increased volcanic tremors/earthquakes were observed again.

In this paper, we identify the crustal deformations associated with these volcanic activities using InSAR time series analysis, determine source locations and change in intensities, and discuss the relation between the time evolution of the sources and observed volcanic activities.

For that purpose, we first analyzed ALOS-2 data (from 2015 to 2018; 8 data) with time series analysis. From the analysis, we identified a pattern of wide crustal deformations over Mt. Azuma. The pattern remains same through time but changes its sign. Deformations corresponding to inflation were observed in 2014-2015, then those corresponding to deflation were observed in 2015-2017, and again those corresponding to inflation were observed in 2018. All these deformations seem to be associated with the spherical pressure source located 3km below sea level (GSI, 2015).

Then we analyzed Sentinel-1 data (from 2018.3 to 2018.11, 21 data) with time series analysis. From the analysis, we identified deformations corresponding to inflation that are localized around the O-ana crater. The deformation rate remains same till September but increased after October.

In this research we re-estimate the source locations/intensities associated with wide/localized deformations, and discuss the relations between time-evolution of those sources and observed volcanic activities.

*Acknowledgment

ALOS-2 data were provided from the Volcano Working Group under a cooperative research contract with JAXA (Japan Aerospace Exploration Agency). The ownership of ALOS-2 data belongs to JAXA.

Keywords: InSAR, Time-series analysis, Mt. Azuma

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The Fault model of the 2017 earthquake (M5.6) in the Eastern flank of Mt. Ontake estimated from precise leveling survey data

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We conducted the precise leveling surveys in the Ontake volcano after the 2014 Mt. Ontake Eruption. The leveling routes of about 38 km with 98 benchmarks were established on the eastern flank of Mount Ontake volcano. The main routes were extended to the Yashikino village (Kakehashi and Yashikino routes). In order to improve the spatial layout of the benchmarks, a branched leveling routes were established (Kiso-Onsen, Ontake Ropeway and Nakanoyu routes).
The M5.6 earthquake occurred just beneath the leveling routes in June 25, 2017. In order to detect the vertical deformation associated with the M5.6 earthquake, we use the leveling data conducted in April 2017, September 2017 and April 2018. In April 2017 and April 2018, All benchmarks were surveyed. In September 2017, the leveling survey was conducted in the Yashikino and Kiso-Onsen routes. The benchmarks of the Yashikino and Kiso-Onsen routes showed uplift in the period from April 2017 to September 2017. The maximum uplift of 28mm was detected in central part of Yashikino route. We also estimate the deformation associated with the earthquake using InSAR method. The deformations detected from the precise leveling and InSAR are similar pattern.
In order to estimate the fault model of the M5.6 earthquake, the single rectangular fault was assumed. The initial parameters of the fault geometry were assumed form hypocenter distribution of aftershocks. Model parameters were optimized using a genetic algorithm (GA) in order to conform to the deformation observed from April 2017 to September 2017.
Acknowledgments: PALSAR-2 data were provided from the PIXEL (PALSAR Interferometry Consortium to Study our Evolving Land surface) under cooperative research contract between JAXA and ERI, University of Tokyo. The original ALOS-2/PALSAR-2 data belong to JAXA. We used the RINC developed by Dr. Takeshi Ozawa. We thank Dr. Taku Ozawa for providing RINC to conduct InSAR analysis.

Keywords: Mt. Ontake, precise leveling, Fault model

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Detection ability of Crustal deformation by Slow Slip Events along the Nankai Trough subduction zone

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1. Introduction

Japan Meteorological Agency (JMA) is monitoring data of the strain-meters in the Tokai region installed by the JMA, Shizuoka Prefecture and National Institute of Advanced Industrial Science and Technology (AIST) to detect a crustal deformation induced by a slow slip event along the Nankai Trough subduction zone. On the other hand, JMA cannot monitor the crustal deformation precisely in the western part of the Nankai Trough subduction zone in real time because of few observation stations in the area except for those installed by AIST. National Research Institute for Earth Science and Disaster Resilience (NIED) installed a high sensitive acceleration-meter with a high sensitive seismograph in a Hi-net station throughout Japan. The acceleration-meter can detect small tilt changes induced by slow slips in Nankai Trough subduction zone. Therefore we expect an improved detection ability of crustal variations by an integrated analysis of the high sensitive acceleration-meter data (tilt data) and the strain data. In this study, we investigated the detection ability of the crustal deformation induced by the slow slip applying the Geodetic Data Stacking method (GDS: Miyaoka & Yokota, 2012 and Miyaoka et al., 2017) to tilt data and strain data.

2. Method

Since the tilt and strain data are affected by ambient noise with responses to solid and oceanic tide, atmospheric pressure, geomagnetic field, and precipitation, we firstly correct these responses. Next, we stacked data to enhance signal to noise ratio in order to detect very small crustal deformations caused by slow slip events. In the procedure of data stacking, we calculate a polarity of the deformation by an assumed small slip on the Philippine Sea (PHS) Plate boundary, and stack them with reversing a polarity of the data with negative calculated change. In this research, we assume a 15km x 15km small fault at each grid point of 0.15 degree intervals for latitude and longtitude on the PHS plate and construct an stacked data at each grid point, which would indicate a distinct positive change if a slow slip occur on the corresponding fault. Then we calculated a smallest moment magnitude at all grid points which exceed the three times of noise magnitude.

3. Result

The detectability of crustal deformation due to slow slips on the PHS plate improved especially around the Kii peninsula and the Shikoku region with adding the tilt data of NIED to the stacked data comparing with that using only strain data. In the presentation, we will show a detection ability of the slow slips on the PHS plate in the Nankai Trough subduction zone as well as a spatial resolution of the monitoring with the GDS method.

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Keywords: Slow Slip Event, Geodetic Data Stacking method, Strain-meter data, Tilt-meter data

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An investigation into slow-slip detection capability of the Tokai Strainmenter Network

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We studied the ability of the Tokai Strainmeter Network (hereinafter referred to as TSN) to detect slow slips on a plate boundary where the Nankai trough earthquakes occur. Referring the method of probability-based magnitude of completeness (hereinafter referred to as PMC) that has been applied to several seismic networks (e.g., [1,2,3]), we modified it to be applicable to TSN. While previous studies on slow-slip detection capability of TSN [4] and the network covering a wider region [5] were based on the model assumption that the medium is elastic and the strainmeters record elastic strain changes caused by slow slips, our study is not based on such model assumption, but uses only empirical data: slow-slip catalog, decfiles, and station information. Using slow-slip events with magnitude *M*5.1-5.8 during 2012-2016, we found spatial variability of network detection probability. In general, the detection probability for slow slips of any given *M* is high within the network or inland, whereas it decreases with distance from the coast to offshore. In more details, the detection probability for *M*5.1 in Suruga Bay is above 90%. Although no strainmeter included in TSN has been installed in Suruga Bay, operating strainmeters on land are located so as to surround this Bay. If we consider a large magnitude such as *M* 5.8, slow slips are detectable even in far offshore regions: for example, slow slips with *M*5.8 at the southern edge of the anticipated source region of the Tokai earthquake can be detected with high (>90%) detection probabilities, a consistent result with [5]. We further explored the possible use of our method as a network planning tool with simulation computations of installations of one or more virtual stations to identify appropriate locations for new station installations [2]. Our results show an illustrative example of the applicability of the PMC method to strainmeter networks.
Acknowledgements: This work was partially supported by JSPS KAKENHI Grant Number JP 17K18958.
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Keywords: strainmeter network, slow slip, Tokai region

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A Study on Trend Component Estimation Method of Strain Time Series Data Using State Space Model

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When detecting some crustal deformation by strain observation data, it is important to eliminate the influence of barometric pressure, tide and precipitation contained in the observation data and to detect the change of the crustal deformation itself. Usually, by investigating the response due to the effect of barometric pressure or the like in advance and separating from the observation value, the true crustal deformation amount is calculated. Another method is to express the time series data of the crustal deformation observation as a state space model and estimate the distribution of the state vector under the condition given the observation data.

In this study, I express time series of strain data observed by Japan Meteorological Agency as state space model, estimate state vector and some parameters by maximum likelihood estimation with Kalman filter algorithm, and separate trend component. In formulating state space expression, observation values at each time point are divided into trend component, barometric pressure response, tidal response, precipitation response, jump effect like co-seismic step or instrument maintenance, and observation errors. Furthermore, in order to attempt formulation by the state space model of the Ishii type strain meter, the term of the response component to the geomagnetism is introduced and also the jump component is not a simple step function but a posteriori effect (including post-seismic deformation or the relaxation of instruments for sudden strain changes) is expressed.

Compared with the conventional method, by using a state space model approach, it is possible to detect change of trend component more stochastically. As a result, it becomes possible to more objectively judge the start and end of crustal deformation, and it is considered that there is an advantage in inversion of deformation sources based on Bayesian method. If parameters of the state space model can be appropriately estimated based on the accumulated observation data, interpolation of missing values, detection of crustal deformation and estimation of sources can be performed in real time.

Keywords: Strain observation, State space model, Objective detection method of crustal change

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Rainfall correction of strainmeter data in consideration of the flow from the upper reaches (2)

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Kimura et al. (2015) showed that the flow from the upper reaches was important for the rainfall correction of the strainmeter data at the Tokai-Region. Therefore, Meteorological Research Institute (MRI) started the research by several method about the rainfall correction of the strainmeter in consideration of the flow from the upper reaches (Kimura, 2015).

The Shimada-Kawane station located near the Minari-River is a high possibility that is influenced by the flow from the upper reaches. MRI installed an ultrasonic water gage at the Minari-River examine improvement of the rainfall correction of the strainmeter data at this station. The continuous observation of the river water level was carried out from March 2015 to December 2016.

We tried several ways of using the observation data of this river water level as input values of the tank model directly, but none of them worked. The reason for this is considered to be that the value of the peak of the river water level is too large relative to the amount of precipitation and has a weight and it is difficult to handle it as input data of the tank model like precipitation data.

As another method, we tried using this tank model and precipitation data observed at the Shimada-Kawane station whether this river water level data can be reproduced. As a result, we found that the residual between the observed value and the calculated value is related to the residual of the rainfall correction of the straimeter data. Although no method has been found yet, it is suggested that there is a possibility that the rainfall correction of the straimeter data can be improved from the river water level observation.

Keywords: strainmeter, rainfall correction, the flow from the upper

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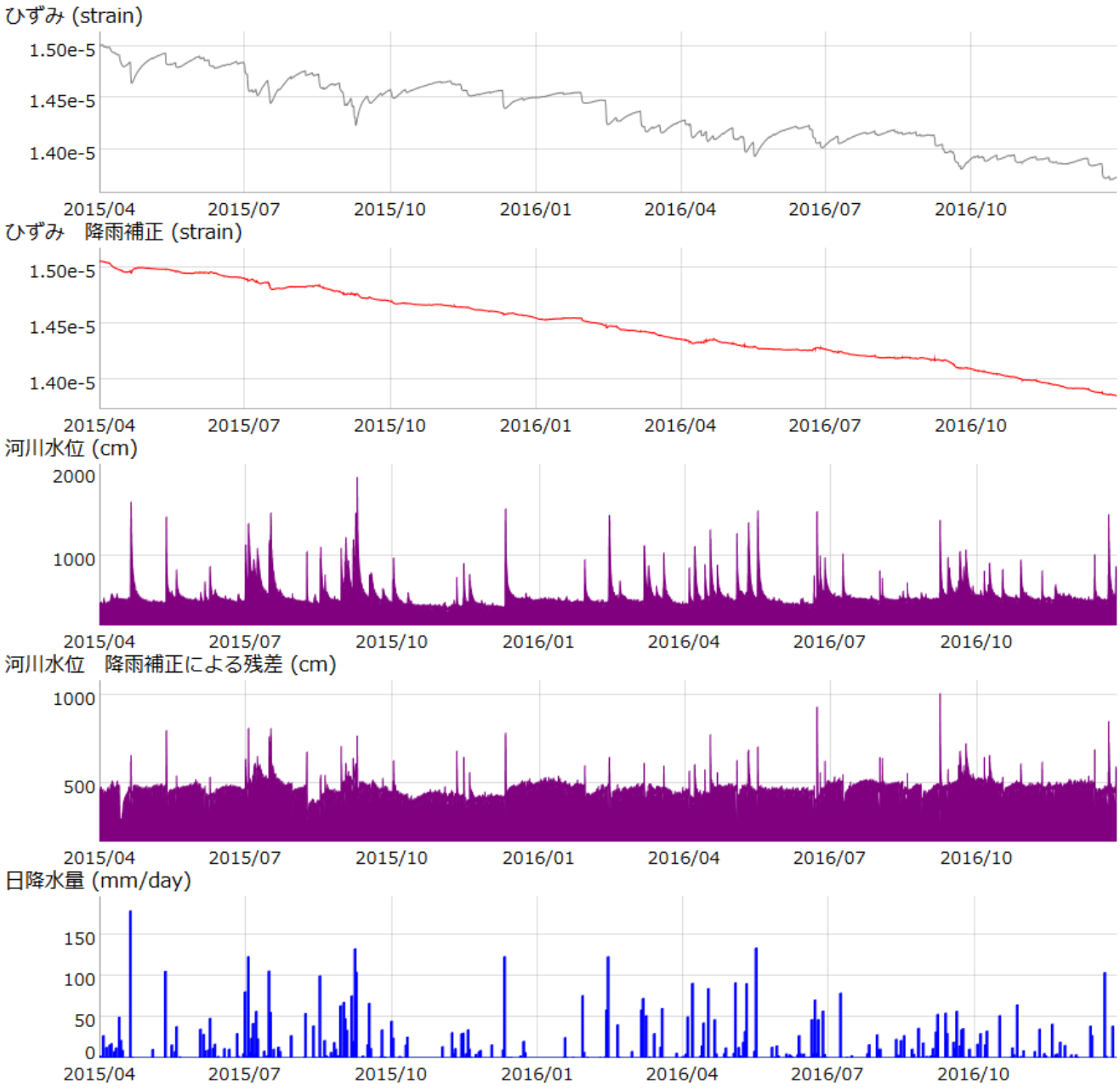

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Long-term slow slip event beneath the Shima Peninsula from 2017 to 2018

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In the Nankai Trough, slow earthquakes such as long-term slow slip events (SSEs) and short-term SSEs have been observed. Long-term SSEs occur around locked fault zones that are considered likely to cause large earthquakes in the future. It is important to characterize the spatiotemporal transitions of long-term SSEs.

We used the daily coordinates of the GEONET F3 analysis operated by the Geospatial Information Authority of Japan. We removed coseismic offsets, artificial offsets, annual and semi-annual variations, and long-term trend. From the displacement from April 2017 to October 2018, the displacement from January 2016 to April 2017 was subtracted for correction of the postseismic deformation. Unsteady displacement in southeast direction about 7-8 mm was seen in the Shima Peninsula.

Assuming that this displacement is due to a long-term SSE, slip distribution on the plate interface was estimated. The estimated slip distribution was located in the Shima Peninsula and moment magnitude was 6.5.

The GNSS F3 coordinate data and offset data were provided by the Geospatial Information Authority of Japan.

Keywords: long-term slow slip event, Shima Peninsula, GNSS

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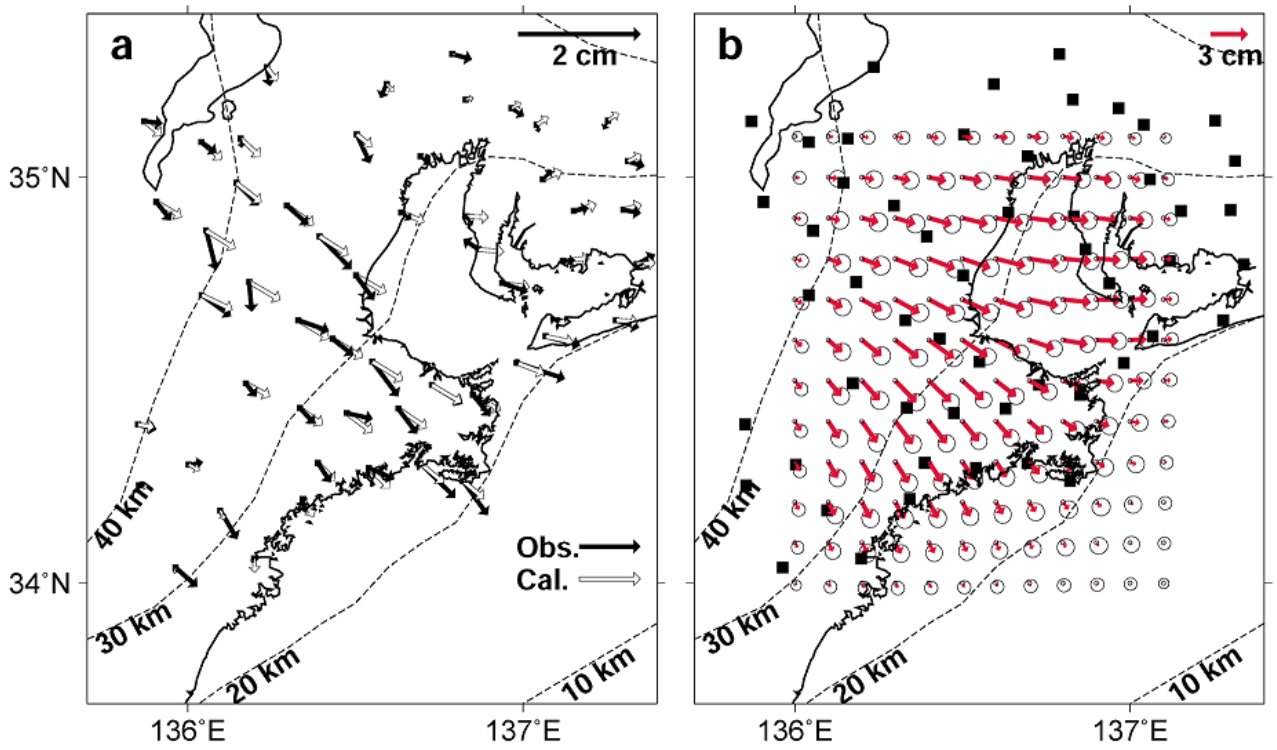

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non- fault slip source components of long-term SSE and the relation to interseismic process preparing for large earthquake generation

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Various types of slow events including slow slip events (SSEs) are detected, and they are explained as fault slip at the plate boundary. However, the mechanism of how to generate a slow event is still open.

From the point of view of the fault strength, source area of slow slip events occurring at the deeper part of the seismogenic zone locate at the brittle-ductile transition zone. The transition from brittle fracture to ductile fracture (or ductile flow) accompany the increase of plastic deformation of rock at the plate interface, and the plastic deformation is not a fault slip at the fault plane but a bulk deformation. If this bulk deformation has an only simple shear component along the plate interface, it is assumed the same as fault slip. On the other hand, if the bulk deformation has the additional mode to the simple shear, the mode is expected to appear as the normal component to the fault plane. Therefore, non-fault slip deformation at the plate boundary, especially normal component, will help to understand the SSE generation mechanism.

Thus our purpose is to detect the non-fault slip deformation at SSE source from observation data, and we select the Tokai long slow slip event (LSSE) because the cumulative Mw is 7.1 and large detectable geodetic signals are expected at GNSS observation points. We examined deformation other than fault slip as Tokai LSSE source by using a finite rectangular fault model with GEONET F3 solution relative displacement in 2001-2003 to 1998-2000 as the reference one. Optimized Tokai LSSE source model of 2yr in 2001-2003 is the finite rectangular fault beneath eastern Aichi Prefecture with 1.6cm tensile dislocation & 9.7cm fault slip, that is, (tensile deformation) : (fault slip) =1:6. This result is better than the case which model has only fault slip component based on AIC (Akaike, 1974).

This result of tensile deformation with fault slip is similar to geological result (e.g., Ujiie et al., 2018). It will help to understand the SSE generation mechanism (e.g., comparing the ratio of tensile dislocation to fault slip). This results depend on the fault geometry; thus source model needs to be reexamined by using realistic plate boundary model along Nankai Trough.

Keywords: slow event, Tokai SSE, generation mechanism, tensile deformation

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Restart of the long-term slow slip events along the Nankai trough after the 2016 Kumamoto earthquake, Japan

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Abstract

Transitional crustal deformation along the Nankai Trough has been observed by GEONET around June 2018. Analysis by time-dependent inversion shows that the long-term SSE occurred in the northern part of Hyuga-Nada Sea from around June 2018 to September and then the slip region moved to the Bungo Channel northeast of 50 km. The sliding area of SSE in 2018 corresponds to the non-slip area of the Hyuga-nada SSE and Bungo channel SSE which were occurring just before the 2016 Kumamoto earthquake. The case of 2018 is a typical example in which long-term SSE was affected by stress perturbation due to a large earthquake, and it gives information on the physical mechanism of SSE. In addition, it has been about 20 years since the last occurrence of the Hyuga-nada earthquake and the probability of the occurrence of the earthquake is 70 to 80% within the next 30 years off the coast of Shikoku. Thus, there is concern about the influence of stress change due to the 2018 SSE on the seismic gap of Hyuga-nada and off the Pacific coast of Shikoku.

Introduction

Along the Nankai Trough, the Hyuga-nada and the Bungo channel long-term SSEs have repeatedly occurred. Long-term SSEs were occurring in Hyuga-nada and Bungo Channel before the 2016 Kumamoto earthquake. Due to the occurrence of the Kumamoto earthquake, SSE in the Hyuga-nada Sea and the Bungo Channel stopped its progress. This is thought to be due to the susceptibility of long-term SSE to stress disturbance caused by a large earthquake. It has been of interest to know when the remaining area of the slip will resume afterwards. Under such circumstances, from around June 2018, transitional crustal deformation was detected by GEONET. The detected transient occurred in northern Kyushu and propagated northeast to the Bungo channel by about 50 km. In this study, we estimated the spatial and temporal evolution of aseismic slip on the plate interface from the observed crustal deformation data by time dependent inversion.

Analytical Method

257 GEONET stations in Shikoku and Kyushu were used in the analysis. From the position time series, the periodic component is estimated from the data of January 2013 to January 2018 and removed from the time series data, after which the linear trend component of January 2017 to January 2018 is removed. The coordinate time series data thus obtained was averaged over 3 days, sampled every 3 days, and used for the time dependent inversion. The analysis period is from January 2018 to January 2019. The weights of east-west, north-south, up-and-down components are set to 5: 5: 1. Hirose et al. (2008) is adopted as a plate boundary model, and it is modeled by a spline surface. The hyperparameters of spatial smoothing and temporal smoothing were estimated by maximum likelihood method.

Result and discussion

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Aseismic slip occurred on the plate interface in the northern part of the Hyuga-nada Sea since around June 2018, subsiding in September. The amount of slippage reaches about 10 cm at the maximum. Since about September, the slip area has moved 50 km to the northeast from the north of Hyuganada to the Bungo Channel. The maximum slippage of the Bungo channel SSE from September 2018 until January 2019 reaches 7 cm. The area slipped at SSE in 2018 corresponds to the area where slip began or did not start in the long-term SSE that occurred until just before the 2016 Kumamoto earthquake. It is thought that reactivation occurred in 2018 two years after the long-term SSE, which stopped due to the stress disturbance accompanying the Kumamoto earthquake in 2016, from the balance between the plate loading and stress relaxation due to viscoelastic deformation. This case is a typical example of stress disturbance to long-term SSE by a large earthquake and very important in understanding the physical process of long-term SSE.

Keywords: slow slip event, Hyuga-nada seas, Bungo channel

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Crustal deformation in the San-in Shear Zone as observed by a dense GNSS network

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The San-in Shear Zone (SSZ) is a right-lateral shear zone in southwest Japan with a 30-50 km width, where active seismicity and high strain rates have been observed. No major active fault is identified in the SSZ, however, deformation in the area can be modeled by assuming a 5 mm/yr deep creep on a vertical fault with right lateral motion and conjugate Riedel shears within the shear zone can reconcile the seismotectonics in the area (Nishimura and Takada, 2017). A model having a deep creep on a vertical fault plane well explains observed GNSS velocity, yet it does not provide how wide aseismic motion is confined below a seismogenic depth. Thus, we evaluate the width of the shear zone beneath the SSZ using GNSS data available in the area.

We analyzed daily coordinates from 100 continuous GNSS stations around the SSZ in the postseismic period of the 2011 M_w9.0 Tohoku-oki earthquake (1 January 2014 to 1 April 2018). The network consists of 87 GEONET stations and original stations in the SSZ operated by Kyoto University since 2014 near the source regions the 2000 Western Tottori (M_w6.6) and the 2016 Central Tottori (M_w 6.2) earthquakes. Horizontal displacement rates are calculated for all stations using linear regression with respect to site 0344 (35.09ºN, 134.59ºE). During the analyzed period two major events affected the crustal deformation in the area: the 2016 Kumamoto earthquakes (M_w 7.0) and the 2016 Central Tottori earthquake. Coseismic and postseismic corrections were applied for the perturbed stations. Viscous relaxation associated with the 2011 Tohoku-oki earthquake is expected to affect the SSZ. This effect was removed employing the 3-dimensional viscosity model by Suito (2017).

The SSZ is characterized by strike-slip motion in the N80ºE direction, thus, we focus on deformation in that component. We evaluate deformation along two profiles, one corresponding to eastern Tottori, where the 2000 Western Tottori earthquake took place, and another considering Central and Eastern Tottori. In order to evaluate the width of the shear zone, we assumed multiple vertical faults located every 0.5 km across the region and optimized the slip rate by minimizing the sum of squares residuals. We fixed the depth of the dislocations to 13 km based on microseismicity studies (Omuralieva et al., 2012).

We found the best fitting models with a different width (i.e., 60 km and 21.5 km) for Western and Central-Eastern Tottori, respectively. They suggest that ductile flow in the lower crust is distributed in a channel beneath the SSZ. However, models with a single vertical fault in the middle of the shear zone are also within the confidence interval. GNSS data alone cannot constrain the width of the shear zone in the lower crust.

Keywords: San-in Shear Zone, GNSS data, The 2011 Tohoku-oki earthquake

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Two-dimensional Fourier series representation of surface deformation: Different scales of crustal deformation

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In the Japan islands, located in a plate subduction zone, we often observe two types of crustal deformation overlap with each other: one is elastic deformation due to slip/slip-deficit at plate boundaries and the other is inelastic deformation (brittle fracture and/or plastic flow) in the crust. In order to understand the crustal deformation and its mechanics precisely, we need to appropriately decompose and analyze these different deformations.

The crustal deformation due to slip/slip-deficit at plate boundaries is usually observed as a long-wavelength pattern in the order of 100 km, since the crustal movements are recorded in land-based InSAR and GNSS observation data at some distance from the plate boundaries. In contrast, the inelastic deformation occurs directly beneath the observation networks, and it is observed as a short wavelength pattern in the order of 10 km. Using the different wavelengths of these two types of crustal movements, some studies have already decomposed them. Takada and Fukushima (2013 Nature Geo.) extracted local subsidence caused by the 2011 Tohoku earthquake from InSAR data by subtracting low-pass filtered interferograms as coseismic deformation due to the earthquake rupture. On the other hand, Meneses-Gutierrez and Sagiya (2016 EPSL) and Meneses-Gutierrez et al. (2018 JGR) used a moving average filter to the strain/strain-rate estimated from GNSS data by the method of Shen et al. (1996) and extracted the long-wavelength components as crustal deformation caused by slip/slip-deficit at a plate boundary.

It would be useful to design filters based on the Fourier spectrum for decomposing different scales of surface deformation, since we can flexibly and systematically extract an arbitrary wavelength band of the surface deformation, which varies in according to the size of deformation source or its distance. In this study, we calculated Fourier spectrum of unequally-spaced GNSS displacement data from 2005 to 2011, and extracted arbitrary wavelength bands of crustal deformation. Firstly, we represented the GNSS displacement data as 2-D Fourier series by superposition of trigonometric functions with discrete wavenumbers, and then estimated the Fourier coefficients sequentially in ascending order of the discretized wavenumbers. The estimated coefficients give the Fourier spectrum in the 2-D wavenumber domain. Secondly, using the derivatives of the basis functions (trigonometric functions), horizontal strain distribution was calculated directly from the estimated coefficients. To validate this method, we synthesized test data of a known displacement field using actual spatial distribution of the GNSS observation stations. It was confirmed that the 2-D Fourier spectrum obtained by our sequential analysis method was almost same as that obtained by the discrete Fourier transform using equally-spaced data.

Applying this method to interseismic GNSS displacement rate data in the Kyushu region, we estimated the horizontal strain rate distribution of long wavelength component (wavelength of 200 km or more) and short wavelength component (wavelength of tens to 200 km) from the result of Fourier transform. The long wavelength component showed a similar pattern as the strain rate distribution theoretically calculated from the slip-deficit rate distribution along the Nankai Trough (Noda et al. 2018 JGR). In the short wavelength component, significant strain rates was localized around Beppu-Shimabara Graben and Sakurajima volcanoes.

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Keywords: GNSS, interseismic crustal deformation, Fourier series expansion, strain rates

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GNSS observation around the shear zone in southern Kyushu (The third report)

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On the basis of strain rate estimation using GNSS velocities, an active shear zone with high shear strain rate more than 10^{-7}/yr is detected in southern Kyushu. However, obvious active faults in the shear zone are not identified. It is inferred that such high shear strain rate is caused by fault slip in a deep part of the earth’s crust. To investigate the crustal deformation in more detail, we installed 10 GNSS sites across the shear zone from north to south and started observations from March in 2016.
Four GEONET sites operated by Geospatial Information Authority of Japan were fixed as reference sites and daily coordinates from April 18, 2016 to November 24, 2018 were determined, using Bernese GNSS Software (ver.5.2). The time series of site coordinates were corrected by subtracting common mode bias, viscoelastic deformation caused by the 2016 Kumamoto earthquake and volcanic deformation due to Sakurajima and Kirishima volcanoes, from the original time series. Then, site velocities together with annual and semi-annual variations were estimated. As for the data before the 2016 Kumamoto earthquake, we also made corrections in time series of GEONET F3 solutions from October 1, 2007 to March 1, 2009, as processing the data acquired after the earthquake.
In this study, we applied site velocities to a vertical strike-slip fault model proposed by Savage and Burford (1973). This model illustrates that a fault is locked from the surface to a certain depth and is sliding at a uniform velocity which is relative rigid block motion below the locking depth. In this case, the profile of surface deformation normal to the fault strike is expressed as a function of arctangent across the fault. However, using the model, locking depth was estimated to be greater value than average thickness of the earth’s crust. Thus, we considered that the center of the shear zone is located more northern part than current assumed location, which means that two unknown parameters, central shift and fault slope toward the north of the shear zone, are added in the analysis in addition to slip velocity and locking depth.
At first, the initial values of above four unknown parameters were determined using the non-linear least-square method to minimize the residuals between observed and calculated velocities, then those unknown parameters were estimated from the 100,000 times sampling performed by the Metropolis-Hastings algorithm of Markov Chain Monte Carlo methods. On comparison of velocity profiles before and after the earthquake, it resulted that the patterns of those crustal deformation were clearly arctangent form and generally in good agreement with each other within 99% confidence limit, which also indicated that the left-lateral strike slip occurs there. The slip velocity and locking depth were estimated to be 12.4-14.3 mm/yr and 15.6-16.6 km. This shows that steady crustal deformation under the shear zone continues after the earthquakes. Meneses-Gutierrez and Sagiya (2016) investigated strain rate in central-northeastern Japan using GPS data before and after the 2011 Tohoku earthquake and observed inelastic deformation due to long-term EW shortening, which is independent of large earthquakes and continues throughout the whole time periods. The result also suggests that a similar phenomenon occurs at a deep region of the shear zone. Moreover, it suggests a possibility that the center of the shear zone is located about 10 km northward compared with the conventional consideration. While unknown parameters such as fault slope do not have a clear peak of posterior distribution, therefore it is necessary to note that there are large uncertainties in them.

This study was carried out by a contract with the Agency of Natural Resources and Energy, part of the

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Ministry of Economy, Trade and Industry of Japan as part of its R&D program supporting development of technology for geological disposal of high-level radioactive waste.

Keywords: active shear zone in southern Kyushu, GNSS observation, left-lateral strike slip, inelastic deformation, the 2016 Kumamoto earthquake

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Post-seismic deformation of 2016 Kumamoto Earthquake by continuous GNSS network (3)

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GNSS observation is ongoing in Kumamoto district to observe post-seismic deformation of 2016 Kumamoto Earthquake. We set up newly twenty continuous GNSS sites until April 30, 2016. Kyushu Univ., Kyoto Univ. and Kagoshima Univ. operate fifteen continuous GNSS sites before the earthquake. Daily coordinates of these sites are estimated by Bernese GNSS Software Ver. 5.2 with CODE precise orbit. ITRF2014 coordinate system is used. In our daily analysis, GEONET data by GSI and data at continuous GNSS sites in active volcanoes by JMA are also used. A dense continuous GNSS network is constructed.

To emphasize post-seismic deformation, trend at each site is removed. Trend is estimated by least squared method by using between 2004 to 2015. For GNSS sites occupied after the earthquake trend is interpolated by using trend at three neighbor sites.

Post-seismic deformation with large deformation is observed at sites which is located in the eastern side of Hinagu faults. Especially amount of deformation in NS component is large. Largest deformation is 13.5cm in the period from April, 2016 to December 2018 at MIFN. In EW component change in deformation occurred in January 2017. Velocity becomes smaller. In these sites post-seismic deformation is continuous at the moment.

Keywords: GNSS, post-seismic deformation

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[J] Poster | S (Solid Earth Sciences)：S-SS Seismology

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_26

[S-SS16] Crustal Deformation

convener:Mako Ohzono(Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University), Tadafumi Ochi(Institute of Earthquake and Volcano Geology, Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Masayuki Kano(Graduate school of science, Tohoku University)

Study of crustal deformation plays an extremely important role in the investigation of wide scale earth dynamics those are earthquake and volcanic activity, plate motion and so on. In our session, we discuss the study related to crustal deformation, such as development of observation instrument, observed crustal deformation, analysis method, and simulation study.

[SSS16-P01] Earthquake Potential in Central Costa Rica based on Geodetic Observations

*Luis Alejandro Carvajal Soto[1], Takeo Ito[1], Hiroshi Kimura[1], Marino Protti Quesada[2] (1.Nagoya University, Earthquake and Volcano Research Center, 2.Observatorio Vulcanológico y Sismológico de Costa Rica, Universidad Nacional)

[SSS16-P02] Crustal deformation along the Liupanshan fault zone derived from GPS

*Weitao Chen[1,2], Weijun Gan[2], Genru Xiao[3], Shiming Liang[2] (1.Development Research Center, China Earthquake Administration, 2.Institute of Geology, China Earthquake Administration, 3.East China University of Technology)

[SSS16-P03] Convergence boundary and velocity between Amur and Okhotsk plates in northern Hokkaido inferred by GNSS velocity data

*Chihiro Ito[1], Hiroaki Takahashi[2], Mako Ohzono[2] (1.Graduate School of Science, Hokkaido University, 2.Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University)

[SSS16-P04] Vertical deformation and repeating earthquakes in southeastern Hokkaido in the last 100 years

*Hiroaki Kobayashi[1,2], Kazuki Koketsu[1], Hiroe Miyake[1] (1.Earthquake Research Institute, The University of Tokyo, 2.Now at Kobori Research Complex. Inc.)

[SSS16-P05] Simple estimation of interplate coupling in the Kushiro-oki and the Nemuro-oki regions, eastern Hokkaido in Japan from onshore GNSS data

*Hiroki Aota[1], Mako Ohzono[2], Fumiaki Tomita[3], Hiroaki Takahashi[2] (1.Department of Earth and Planetary Sciences, School of Science, Hokkaido University. , 2.ISV, Faculty of Science, Hokkaido University, 3.Graduate School of Science, Hokkaido University)

[SSS16-P06] Estimation of the early afterslip location of the 2011 Tohoku-Oki earthquake using onshore GNSS and offshore pressure data

*Putra Maulida[1], Yusaku Ohta[1], Ryota Hino[1] (1.Graduate School of Science, Tohoku University)

[SSS16-P07] Heterogeneous rheology structure estimated by the postseismic deformation following the 2011 Tohoku-Oki earthquake (M_w9.0)

*Yoshiaki Ito[1,2], Satoshi Miura[2], Jun Muto[2], Yusaku Ohta[2], Takeshi Iinuma[3], James Daniel Paul Moore[4] (1.Mitsubishi Space Software Co., Ltd., 2.Graduate School of Science, Tohoku University, 3.Japan Agency for Marine-Earth Science and Technology, 4.Nanyang Technological University)

[SSS16-P08] Contribution of linear and non-linear viscoelastic relaxation as postseismic deformation following an earthquake

*Hiroyuki Hoshino[1], SHINICHI MIYAZAKI[2,1], Kazuro Hirahara[2] (1.Graduate school of science, Kyoto University, 2.Institute of Education, Research and Regional Cooperation for crisis Management Shikoku, Kagawa University)

[SSS16-P09] Estimation of fault parameter with maximum ΔCFS based on GNSS data

*Shuntaro Fukaya[1], Mako Ohzono[2] (1.School of Science, Hokkaido University, 2.ISV, Faculty of Science Hokkaido University)

[SSS16-P10] Coseismic deformation of the 2018 Lombok earthquake, Indonesia, revealed through InSAR measurements

*ERLAN SUMANJAYA[1], MASATO FURUYA[1] (1.Hokkaido University)

[SSS16-P11] Recent crustal deformations around Mt. Azuma revealed by InSAR time-series analysis

*Hiroshi Munekane[1], Tomokazu Kobayashi[1] (1.GSI of Japan)

[SSS16-P12] The Fault model of the 2017 earthquake (M5.6) in the Eastern flank of Mt. Ontake estimated from precise leveling survey data

*Masayuki Murase[1], Naoka Kitazume[1], Yoshiko Yamanaka[2], Takeshi Matsushima[3], Fumiaki Kimata[7], Hitoshi Yamashita Mori[1], Takamasa Hase[1], Yang Li[1], Kazuki Ofuchi[1], Takahiro Kunitomo[2], Yuta Maeda[2], Shinichiro Horikawa[2], Takashi OKUDA[2], Kenjiro Matsuhiro[2], Kazushi Tanoue[2], Kazunari Uchida[3], Yoshiko Teguri[3], Rintaro Miyamachi[3], Kaori Morita[3], Yoshikawa Shin[4], Hiroyuki Inoue[4], Isao Kageyama[5], Syuichi Hosokawa[5], Takahiro Yanada[5], Rinah Tanaka[1], Ryosuke Doke[6] (1.Department of Earth and Environmental Sciences, College of Humanities and Sciences, NIHON University, 2.Graduate School of Environmental Studies, Nagoya University, 3.Graduate School of Sciences, Kyushu University, 4.Graduate School of Sciences, Kyoto University, 5.Japan Meteorological Agency, 6.Hot Springs Research Institute of Kanagawa Prefecture, 7.Tono Research Institute of Earthquake Science)

[SSS16-P13] Detection ability of Crustal deformation by Slow Slip Events along the Nankai Trough subduction zone

*Kazuki Miyaoka[1], Reiko Kai[1], Takeshi Kimura[2], Takahiro Tsuyuki[3] (1.Japan Meteorological Agency, 2.National Research Institute for Earth Science and Disaster Resilience, 3.Meteorological Research Institute)

[SSS16-P14] An investigation into slow-slip detection capability of the Tokai Strainmenter Network

*Kazuyoshi Nanjo[1] (1.University of Shizuoka)

[SSS16-P15] A Study on Trend Component Estimation Method of Strain Time Series Data Using State Space Model

*Takahiro Tsuyuki[1] (1.Meteorological Research Institute)

[SSS16-P16] Rainfall correction of strainmeter data in consideration of the flow from the upper reaches (2)

Kazuhiro Kimura[1], *Akio Kobayashi[2] (1.Japan Meteorological Agency, 2.Meteorological Research Institute, Japan Meteorological Agency)

[SSS16-P17] Long-term slow slip event beneath the Shima Peninsula from 2017 to 2018

*Akio Kobayashi[1], Takahiro Tsuyuki[1] (1.Meteorological Research Institute, Japan Meteorological Agency)

[SSS16-P18] non- fault slip source components of long-term SSE and the relation to interseismic process preparing for large earthquake generation

*Noa Mitsui[1], Takeo Ito[2] (1.Tono Research Institute of Earthquake Science, 2.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University)

[SSS16-P19] **Restart of the long-term slow slip events along the Nankai trough after the 2016 Kumamoto earthquake, Japan**

*Shinzaburo Ozawa[1], Hiroshi Yarai[1] (1.Geographical Survey Institute of Japan)

[SSS16-P20] Crustal deformation in the San-in Shear Zone as observed by a dense GNSS network

*Angela Meneses-Gutierrez[1], Takuya NISHIMURA[1] (1.Disaster Prevention Research Institute, Kyoto University)

[SSS16-P21] Two-dimensional Fourier series representation of surface deformation: Different scales of crustal deformation

*Akemi Noda[1], Tatsuhiko Saito[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[SSS16-P22] GNSS observation around the shear zone in southern Kyushu (The third report)

*Tsuyoshi Watanabe[1], Atsushi Saiga[2], Koichi Asamori[1], Hiroki Ogawa[1], Akiomi Shimada[1], Koji Umeda[3] (1.JAEA, Tono Geoscience Center, 2.JAEA, Horonobe Underground Research Center, 3.Hirosaki University)

[SSS16-P23] Post-seismic deformation of 2016 Kumamoto Earthquake by continuous GNSS network (3)

*Shigeru Nakao[1], Takeshi Matsushima[2], Takao Tabei[3], Makoto OKUBO[3], Tadashi Yamashina[4], Takahiro Ohkura[5], Takuya NISHIMURA[7,6], Takuo Shibutani[6], Masahiro Teraishi[6], Takeo Ito[7], Takeshi Sagiya[8], Kenjiro Matsuhiro[7], Teruyuki Kato[9], Jun'ichi Fukuda[9], Atsushi Watanabe[9], Satoshi Miura[10], Yusaku Ohta[10], Tomotsugu Demachi[10], Hiroaki Takahashi[11], Mako Ohzono[11], Teruhiro Yamaguchi[11], Kazumi Okada[11] (1.Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University, 2.Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 3.Department of Global Environment and Disaster Prevenction, Faculty of Science and Technology, Kochi University,, 4.Kochi Earthquake Observatory, Faculty of Science and Technology ,Kochi University, 5.Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 6.Disaster Prevention Research Institute, Kyoto University, 7.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University, 8.Disaster Mitigation Research Center, Nagoya University, 9.Earthquake Research Institute, University of Tokyo, 10.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University,, 11.Institute of Seismology and Valcanology, Graduate School of Science, Hokkaido University)

Earthquake Potential in Central Costa Rica based on Geodetic Observations

*Luis Alejandro Carvajal Soto[1], Takeo Ito[1], Hiroshi Kimura[1], Marino Protti Quesada[2]

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The Central Costa Rica Deformed Belt is the extension of the North Panama Deformed Belt, a diffuse predominant northwest dextral-strike and conjugated northeast sinistral-strike faulting area, that represents the western border of the Panama Microplate. This diffuse boundary crosses Central Costa Rica from the Caribbean Coast, including the active Cordillera Volcanica Central, the Metropolitan Area (most dense population area in Costa Rica) and the Central Pacific coastline to intersects the Meso American Trench along the subduction of the Cocos Plate.

We integrated interseismic geodetic data with seismicity records and inland faulting traces in other to evaluate earthquake potential in 4 kinematic models with different spatial geometries of the tectonic configuration around Central Costa Rica. Crustal deformation in Central Costa Rica and surroundings is modeled as result: i.kinematic effects of rigid block motions, ii.elastic deformation due to the interaction on subduction and inland tectonic interfaces and iii.internal strain of each tectonic block. We adopted the Markov Chain –Monte Carlo method in order to approximate the solution for each kinematic model.

Our estimation of the velocity field in Costa Rica suggests that the crustal deformation in Costa Rica is mainly arranged in three groups: 1). Northwestern Costa Rica is dominated by a northward deformation with rates up to 30 mm a^{-1}, rotating and decreasing up to 20 mm a^{-1} northwestward following the Central American Forearch. 2). Southeastern Costa Rica shows deformation to the North-east up 40 mm a^{-1} (opposite to northwestern Costa Rica). 3). Central Costa Rica is characterized by a diffuse deformation pattern oriented mainly to northward, with deformation rates up a half of those observed in northwestern and southeastern Costa Rica. According to the values of slip deficit in interfaces of each model and analysis of local seismicity, we provide results about the earthquake potential in Central Costa Rica, where it is possible to reach earthquakes higher than Mw. 6.5 in all models.

Keywords: Central Costa Rica, Earthquake potential Costa Rica, Crustal Deformation Costa Rica

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Crustal deformation along the Liupanshan fault zone derived from GPS

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The Liupanshan fault zone is located in North Central of North-South Seismic Belt, which is the boundary between the northeastern margin of the Tibetan Plateau and Ordos. This study collected 261 GPS stations distributed around the Liupanshan fault zone. 249 stations are belong to CMONOC and start to observe since 1999, 15 stations are constructed by this study and start to observe since 2013. GPS data are processed with the software GIPSY/OASIS (Version 6.0) from JPL, using the Precise Point Positioning (PPP) strategy and JPL products to obtain daily loosely constrained solutions. The result shows that the northern section of fault zone has a relatively weak left-lateral strike slip and 1.5mm/yr dip slip rate, but no significant difference motion is observed on both sides of the southern section. Furthermore, the maximum principal strain rates indicate that the deformation characteristic of the fault is extrusion, and the value gradually decreases from north to south.

Keywords: GPS, Crustal Deformation, Liupanshan Fault

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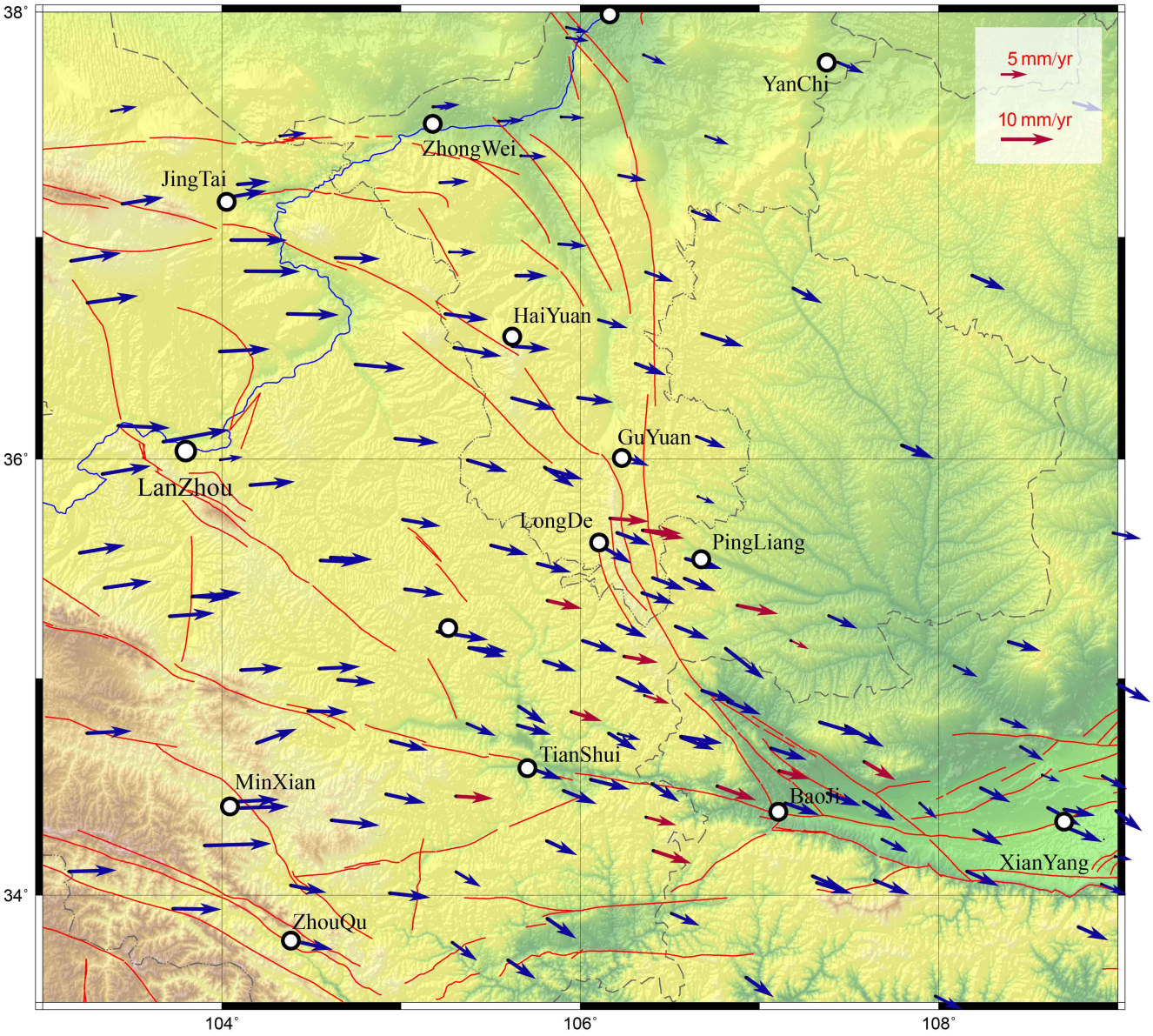

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Convergence boundary and velocity between Amur and Okhotsk plates in northern Hokkaido inferred by GNSS velocity data

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Tectonics of east Asia especially around Japan are complex. Earthquakes at the eastern margin of the Japan sea are due to interaction of plates, and some huge events occurred. However, there is absence of seismicity at west off northern Hokkaido; between focal regions of Shakotan-oki earthquake in 1940 (M7.0) and southwest off Sakhalin earthquake (M7.1). Sarobetsu active fault zone is located onshore of northern Hokkaido, the Japan Sea side, and pointed that it has potential of earth quake generation over M7.6 by the Headquarters for Earthquake Research Promotion. In northern Hokkaido, a boundary between Amur and Okhotsk plates has been assumed. Its geometry has been in debate, and there are many plate boundary models. In addition, distribution of seismic activity and geological structure indicate there is difference of the structure between west and east parts.

Several block models are constructed, and the boundary is estimated by using geodetic data in this region (e.g., Loveless and Meade, 2010), but comprehensive discussion considering geological structure, the Bouguer gravity anomaly and earthquake distribution is lacked. To verify the insistence that the boundary between Amur and Okhotsk plates exists onshore in northern Hokkaido, we estimate the location of the boundary, convergence velocity and elastic thickness applying a dislocation model for collision zone by Shimazaki and Zhao (2000) to represent velocity field observed by Global Navigation Satellite System (GNSS). Most of previous studies for northern Hokkaido fixed location of the boundary arbitrary. Therefore, we treated the boundary location as unknown parameters and estimate it in this study.

Estimated location of the collision boundary is in ENE-WSW direction and roughly consistent with boundary of seismicity, geological structure, and Bouguer gravity anomaly. Geological structures would behave as a kinematic boundary. Estimated thickness of elastic zone is 21.6-28.8 km. Indicator of seismic activity in vertical direction; D90’ s and Moho depth are 20-30 km and 30 km, respectively. In this model, determination accuracy of thickness is lower than the other parameters, however consistent with the discontinuous depth indicates that estimation of other parameters would show plausible value. Estimated velocity is 13.7-18.9 mm/yr, and these values are consistent with results by other studies that estimated velocity between some plates. The boundaries that estimated by discrete data, geology, seismology, and our result, roughly consistent with each other. Therefore, possibility that the boundary between Amur and Okhotsk plates is located onshore of northern Hokkaido became increasingly high.

Keywords: GNSS measurements, crustal deformation, collision zone, northern Hokkaido

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Vertical deformation and repeating earthquakes in southeastern Hokkaido in the last 100 years

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In the southernmost part of the Kuril subduction zone, six large to giant interplate earthquakes have occurred in the last 400 years. This includes the two M_w ~ 8 Tokachi-oki earthquakes that occurred in 1952 and 2003. In Hokkaido, instrumental seismic and geodetic observations began in the late 19th to early 20th centuries. Therefore, we are able to investigate more than a single M8 class earthquake cycle there using the observation data.
In this study, we investigated leveling data and repeating earthquakes in southeastern Hokkaido in the last 100 years. For the leveling data, we chose the survey route around Cape Erimo because the survey was conducted in 1952 and 1953 after the 1952 earthquake, the route has not changed since the first survey and is located near the coast, and there is likely no subsidence due to the pumping of underground water. We also estimated the crustal deformation due to medium-sized (M larger than or equal to 6.5) earthquakes since 1908 by simple uniform slip models. For some earthquakes, we estimated the focal mechanisms by analyzing the analog seismograms and the first motion polarity data.
For the investigation of the historical occurrences of repeating earthquakes, we chose two groups around Hokkaido whose average M_{JMA} is 5.4 from the catalogs of Uchida and Matsuzawa (2013) and Seismology and Volcanology Research Department of Meteorological Research Institute et al. (2014). Using the JMA catalog, we selected earthquakes occurring prior to 1993, whose epicentral distance from the known repeating earthquakes was less than 20 km and whose M_{JMA} was between 5.1 and 5.7. In addition, we checked a few earthquakes whose epicentral distances were less than 30 km. We used the the Headquarters for Earthquake Research Promotion data retrieval system to obtain copies of the analog seismograms and determined the repeating earthquakes by visual comparisons. We also estimated the aseismic slip rate around the groups.
The results of these investigations reveal that the afterslip of the 1952 earthquake may have continued until around 1980. Moreover, in the Tokachi-oki region, the state of the plate interface prior to the 1952 earthquake may be similar to that prior to the 2003 earthquake. Furthermore, the acceleration of aseismic slip around 1980 can be found in the west of Cape Erimo.

Keywords: Leveling data, repeating earthquake, analog seismogram, Tokachi-oki region

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Simple estimation of interplate coupling in the Kushiro-oki and the Nemuro-oki regions, eastern Hokkaido in Japan from onshore GNSS data

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It is important to understand interplate coupling conditions on plate interface to upcoming earthquake occurrence. The interplate coupling along the Kurile trench in the Kushiro–Nemuro-oki region eastern Hokkaido in Japan, have been discussed by many previous studies using onshore geodetic data (e.g., Hashimoto et al., 2009), and most of them estimated high coupling ratio in around the region during the interseismic period. A study of tsunami analysis points out the possibility of a great earthquake occurrence along the shallow part of this area in 17th century(Ioki and Tanioka 2016). Therefore, there is a possibility that a great earthquake will occur in the future. Under those background in this area, there is a plan to install two GNSS-Acoustic (GNSS-A) observation sites on the seafloor to understand the interplate coupling more precisely, especially for near the trench. As the preliminary research, we estimate interplate coupling ratio and its distribution around this region from onshore GNSS data (GEONET), and confirm the constrain limit of the result for sea area. We construct simple backslip model(Sanvage, 1983) in an elastic half-space(Okada, 1992), we calculated several synthetic profiles of the displacement rate due to the plate coupling assuming various coupling ratios and various ranges of the coupling zone, and we explored an optimal condition to explain the profile of the observed displacement rates. As a result, using the horizontal component data, coupling ratio, depth of the up-dip limit and of the down-dip limit of the coupling zone was calculated to be 1.0–1.1, 0–5 km and 50–55 km, respectively. In this result, coupling ratio was over 1.0. The reason of this high coupling ratio is probably caused by small plate convergence velocity (8.4 cm/yr)(Altami et al., 2016) we assumed in this study, and/or ignorance of viscoelastic effect in the asthenosphere. The estimated coupling zone is deeper than that of the previous studies(e.g., Hashimoto et al., 2009). This might be caused by our simple assumption of a uniform dip-angle of the plate interface fixed to 15 degrees. As for the actual geometry of the plate interface, the dip angle is increased with depth; thus, we should consider it for the next modeling. As previous studies(e.g., Hashimoto et al., 2009) suggested, it is difficult to constraint the interplate coupling condition of shallow part around the trench only from onshore geodetic data. Meanwhile, in order to find the appropriate GNSS-A installation areas, we explored locations sensitive to the fault parameters for the shallow coupling by comparing the above synthetic profiles of the placement rates. As a result,, we determined two points as candidates at 25 km and 40 km from the trench axis considering the detection limits of the observations, which correspond to the following the conditions: (1) a point demonstrating clear differences among the velocity profiles depending on special extent of the coupling area, and (2) a point demonstrating a large inclination of each profile. Since our estimation is simple due to the ignorance of the underground rheological structure and of the distilled plate geometry, it is necessary to update the modeling results by considering the above matters and other additional geophysical information, such as seismic activities in this region.

Keywords: Earthquake, Crustal deformation, Interplate coupling

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Estimation of the early afterslip location of the 2011 Tohoku-Oki earthquake using onshore GNSS and offshore pressure data

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Understanding of spatial and temporal development of the early afterslip just after the large earthquake is extremely important to characterize the frictional properties vicinity of an earthquake. Widely installed onshore geodetic data has been utilized to estimate the frictional properties along the plate interface (e.g. Miyazaki et al., 2004). One of the opportunity to study for early afterslip of the large event is 2011 Tohoku-Oki Earthquake. Dense continuous GNSS was installed nationwide, which had captured whole time period for this event successfully. Thus, we focus on the early afterslip of the 2011 Tohoku-Oki event in this study using both of onshore GNSS and offshore pressure data.

For the onshore GNSS data, we estimated the every 30 seconds kinematic time series until 18 hours after the mainshock. To enhance the signal-to-noise ratio of kinematic time series, we applied the principle component analysis (PCA) for kinematic PPP time series. We removed the lower contribution components from raw time series. For the offshore pressure data, we used the data-set by Hino et al. (2014). The raw OBP time series was sampled into 1 minute, after taking 1 minute average of raw data. Next, the resampled pressure data were de-tided, de-drifted and corrected by the ocean model to detect the seafloor deformation (Inazu et al, 2012). The time series of corrected OBP showed a strong signal of tsunami wave propagation. To clearly showed the tectonic deformation of the seafloor, we applied moving average of a window of (time with of windows) in length. The amount of displacement was estimated based on logarithmic functions fitted to the filtered pressure records.

To estimate the spatial and temporal development of early afterslip, we applied a conventional network inversion filter (NIF) (Segall and Matthews, 1997). We assumed an elastic half-space model (Okada, 1992) to calculate green functions of surface displacement due to slips on subfaults. We assumed local benchmark motions in unknown state vectors. To reduce the number of unknown parameters, we assumed pure reverse faulting. We omitted 10 minutes parts just after the mainshock from both onshore and offshore data because of the large disturbance caused by the seismic wave passage.

We estimated the early afterslip distribution using two different data sets for comparison. First one is the result from the onshore GNSS data only. Second one is the result both from the onshore GNSS and the offshore pressure data. Using only the onshore data, the estimated afterslip mainly concentrate on the deeper extension of the coseismic slip distribution. Spatial pattern of the estimated afterslip consistent with previous study (e.g. Munekane et al. 2012). In contrast, obtained early afterslip distribution completely difference when we included the offshore data. The estimated afterslip mainly concentrated in the shallower part of the subducting plate interface. Estimated moment release amount reached 2.37 x 10^{21} Nm (correspond to Mw 8.24) after the 18 hours from the mainshock. It clearly larger than the previous studies such as Munekane et al [2012]. It may be caused by the offshore pressure data. Just after the 2011 Tohoku-Oki event, all of the ocean bottom pressure time series indicate the clear subsidence signal. To explain this subsidence, afterslip cannot locate in the deeper part of the subducting plate interface because the afterslip in the deeper part generate the upward displacement in the ocean bottom pressure sites.

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We will discuss the more detail characteristic of the estimated early afterslip distribution. We also try to estimate the afterslip distribution using L1 regularization inversion (e.g. Evans et al., 2012) approach to illuminate the location of the afterslip just after the mainshock.

Keywords: Early afterslip, Ocean Bottom Pressure, GNSS, Network Inversion Filter

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Heterogeneous rheology structure estimated by the postseismic deformation following the 2011 Tohoku-Oki earthquake (M_w9.0)

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The 2011 Tohoku-Oki earthquake (M_w9.0) was the largest earthquake ever recorded in Japan and triggered substantial and long-lived postseismic deformation. We investigate the characteristics of the postseismic deformation based on the across-arc dense GNSS network running between Iwaki and Niigata cities (Ban-Etsu line) operated by the Geospatial Information Authority of Japan (GSI) and Tohoku University. Using the network, estimated the heterogeneous viscoelastic structure to reproduce the observed 5-year-displacements and their time series. It is revealed that both local subsidence during the first 2 years and gradient changes in all displacement components during latter 3 years occurred around the volcanic front (VF). To evaluate the time series of postseismic deformation, we normalized the horizontal scalar displacements by the total displacements in 5 years to define “relaxation rate.” Picking up the date when the relaxation rate reaches every 0.1 interval from 0 to 1, we obtain “relaxation rate profile (RRP).” The RRP shows that the relaxation rates are generally high and low in the fore-arc and back-arc regions, respectively, together with the relatively higher rate 350 to 400 km apart from the trench. We employed the integral method called Unicycle (Lambert and Barbot, 2016; Barbot et al., 2017) to conduct a three-dimensional modeling of the postseismic deformation considering the afterslip and viscoelastic relaxation. The former is governed by the rate-strengthening friction approximation (Barbot et al., 2009) and the latter is based on power-law Burgers model (Masuti et al., 2016). The viscoelastic parameters were optimized by means of a grid search with minimizing RMS (root mean square). The optimum viscoelastic structure has a low viscosity zone (LVZ) beneath VF and the “cold nose (CN)” region from the trench to around VF, and is consistent with the resistivity structure estimated by Uyeshima et al. (2016) and with the spatial extent of CN deduced by Freed et al. (2017). The model reproduced the overall characteristics of the displacement and the RRP, while the detailed characteristics such as flat pattern 350 to 400 km apart from the trench cannot be replicated. Varying the LVZ’s extent and viscosity, we obtained a better model with the LVZ at 25-55 km in depths to fit the observed characteristics, but more considerations are necessary. However, our best model for the Ban-Etsu line cannot be applicable to a northern across-arc profile, Naruko line of Muto et al. (2016), implying the along-arc heterogeneity of viscoelastic structure. Then, we examined the along-arc heterogeneous CN models, a better model with small extent of the CN in the northern area and the spot-like LVZ beneath the active volcanoes is estimated. The final model explains the observed displacements and also the areal strain distribution (Miura et al., 2014). This suggests the importance of considering not only across-arc but also along-arc heterogeneous viscoelastic structure to explain the observed postseismic deformation of the Tohoku-oki earthquake.

Keywords: postseismic deformation, Tohoku-oki earthquake

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Contribution of linear and non-linear viscoelastic relaxation as postseismic deformation following an earthquake

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Postseismic deformation following the 2011 Tohoku-oki earthquake has been observed at GPS and GPS/Acoustic stations. Previous studies have estimated the contribution of viscoelastic relaxation as the postseismic mechanism as well as afterslip. Those studies employed Maxwell rheology or Burgers rheology for asthenosphere. Some studies advocate non-linear rheology. However, it is still unclear which rheology is the most suitable to the real Earth.

Barbot and Fialko (2010) presented a theory that represent any types of postseismic processes given the constitutive equations. Viscoelastic relaxation, afterslip and poroelastic rebound were involved in the theory. This representation enables us to use both linear and non-linear viscoelastic rheology as postseismic viscoelastic relaxation. In this study, we developed a numerical code referencing this theory. The process of the calculation is following. (1) Coseismic displacements and stress changes are calculated based on Okada (1992). (2) In each time step, the field of moment density rate derived from the postseismic mechanisms is calculated analytically given the stress field. (3) Fields of velocity and strain rate are calculated from the moment density rates. (4) Fields of displacement and stress at the next time step are obtained by integrating velocities and stress rates with time, respectively.

In this presentation, we calculate postseismic deformation including viscoelastic relaxation, for a dip-slip and a strike-slip earthquakes. Results for different rheology models are compared to examine the suitable model to reproduce the characteristics of postseismic displacement data. We plan to compare calculated results with the observed postseismic GNSS data following earthquakes, such as the 2011 Tohoku-oki earthquake.

Keywords: rheology, postseismic deformation, viscoelastic relaxation

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Estimation of fault parameter with maximum ΔCFS based on GNSS data

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In order to estimate fault parameter (strike, dip and rake), which has the maximum ΔCFS (coulomb failure stress) at each area, we analyze horizontal GNSS data and compared the results with existing active faults. The ΔCFS is useful information to assess whether the fault tends to slip or not, based on stress redistribution induced by stress disturbances such kind of large earthquakes. Although the ΔCFS is calculated assuming source fault and its dislocation theory in general, Ueda and Takahashi (2005) and Nishimura (2018) propose an effectiveness of ΔCFS calculation from surface strain distribution observed by GNSS data. In this study, we apply this approach and search fault parameters that has the maximum ΔCFS at each area. For the test case, we calculated ΔCFS for an active fault, Yamagata-basin fault zone, using GEONET data before and after the 2011 Tohoku-oki earthquake. As a result, calculated stress field and estimated fault parameters before the earthquake well corresponds to the geometry of the actual active fault. From this test, we also found that this method calculates the ΔCFS with dip-dependency. This is due to the absence of vertical information in our method. Under the constraint of dip angle, we apply this method for Tohoku region using horizontal displacement data from September 2004 to September 2007, then we compared the result and active faults database. As a result, the region that shows high value of ΔCFSs and its fault parameters correspond to the region that evaluated S rank (category of high risk) and X rank (evaluation is difficult because of few data) faults announced by the Earthquake research committee. We also found high value of ΔCFS area even in areas without active faults. The source region of the 2008 Iwate-Miyagi inland earthquake is one of them. The estimated fault parameters with high ΔCFS also correspond to the fault mechanism of it. If the strain and stress estimated from horizontal GNSS data is caused by elastic accumulation on the fault, our method probably useful for future fault slip assessment on the current high ΔCFS fault at each area.

Keywords: ΔCFS, GNSS, active fault

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Coseismic deformation of the 2018 Lombok earthquake, Indonesia, revealed through InSAR measurements

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Interferometric Synthetic Aperture Radar (InSAR) is a space-based technique allowing to derive images of ground surface deformation. This method is based on repeated acquisitions by a Radar system onboard a satellite. We use Advanced Land Observing Satellite-2 (ALOS-2)/Phased Array-type L-band Synthetic Aperture Radar-2 (PALSAR-2) InSAR data sets from ascending stripmap mode and descending ScanSAR data. Meanwhile, we also use JAXA’ s AW3D DEM to correct for the topographic phase. These datasets allow us to more completely detect the deformation signal around the epicentral region caused by three Mw > 6 shallow earthquakes occurred in Lombok island, Indonesia. These events are of almost dominant thrust mechanism using GCMT solutions. The results show that the maximum amplitude of the line of sight (LOS) displacements are covering the mainshock of 35 cm in ascending and 30 cm in descending observations which is close to the epicenter of the earthquake. Both of which indicate that the surface was approaching toward the satellite. Because of ALOS-2 interferogram images are affected by ionospheric disturbances; therefore, we also perform ionospheric correction using split spectrum method (SSM), and the result shows that no signal of the ionosphere is detected there so that we can ignore the effect of the ionosphere. Meanwhile, to find slip distribution around the epicentral area, we plan to generate a fault source model using triangular dislocation element in an elastic halfspace.

Keywords: The 2018 Lombok earthquake , Coseismic deformation, InSAR

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Recent crustal deformations around Mt. Azuma revealed by InSAR time-series analysis

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Mt. Azuma is a complex volcano on the border of Fukushima/Yamagata pref., located approximately 200 km north of Tokyo. Increased volcanic tremors/earthquakes were observed in 2014 around Mt. Azuma that associate inflations around Mt. Issaikyo, one of the peak within the complex. Correspondingly, enhanced geothermal activities were observed around the O-ana crater between 2013 and 2015. These activities had ceased in 2016, but then in 2018, increased volcanic tremors/earthquakes were observed again.

In this paper, we identify the crustal deformations associated with these volcanic activities using InSAR time series analysis, determine source locations and change in intensities, and discuss the relation between the time evolution of the sources and observed volcanic activities.

For that purpose, we first analyzed ALOS-2 data (from 2015 to 2018; 8 data) with time series analysis. From the analysis, we identified a pattern of wide crustal deformations over Mt. Azuma. The pattern remains same through time but changes its sign. Deformations corresponding to inflation were observed in 2014-2015, then those corresponding to deflation were observed in 2015-2017, and again those corresponding to inflation were observed in 2018. All these deformations seem to be associated with the spherical pressure source located 3km below sea level (GSI, 2015).

Then we analyzed Sentinel-1 data (from 2018.3 to 2018.11, 21 data) with time series analysis. From the analysis, we identified deformations corresponding to inflation that are localized around the O-ana crater. The deformation rate remains same till September but increased after October.

In this research we re-estimate the source locations/intensities associated with wide/localized deformations, and discuss the relations between time-evolution of those sources and observed volcanic activities.

*Acknowledgment

ALOS-2 data were provided from the Volcano Working Group under a cooperative research contract with JAXA (Japan Aerospace Exploration Agency). The ownership of ALOS-2 data belongs to JAXA.

Keywords: InSAR, Time-series analysis, Mt. Azuma

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The Fault model of the 2017 earthquake (M5.6) in the Eastern flank of Mt. Ontake estimated from precise leveling survey data

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We conducted the precise leveling surveys in the Ontake volcano after the 2014 Mt. Ontake Eruption. The leveling routes of about 38 km with 98 benchmarks were established on the eastern flank of Mount Ontake volcano. The main routes were extended to the Yashikino village (Kakehashi and Yashikino routes). In order to improve the spatial layout of the benchmarks, a branched leveling routes were established (Kiso-Onsen, Ontake Ropeway and Nakanoyu routes).
The M5.6 earthquake occurred just beneath the leveling routes in June 25, 2017. In order to detect the vertical deformation associated with the M5.6 earthquake, we use the leveling data conducted in April 2017, September 2017 and April 2018. In April 2017 and April 2018, All benchmarks were surveyed. In September 2017, the leveling survey was conducted in the Yashikino and Kiso-Onsen routes. The benchmarks of the Yashikino and Kiso-Onsen routes showed uplift in the period from April 2017 to September 2017. The maximum uplift of 28mm was detected in central part of Yashikino route. We also estimate the deformation associated with the earthquake using InSAR method. The deformations detected from the precise leveling and InSAR are similar pattern.
In order to estimate the fault model of the M5.6 earthquake, the single rectangular fault was assumed. The initial parameters of the fault geometry were assumed form hypocenter distribution of aftershocks. Model parameters were optimized using a genetic algorithm (GA) in order to conform to the deformation observed from April 2017 to September 2017.
Acknowledgments: PALSAR-2 data were provided from the PIXEL (PALSAR Interferometry Consortium to Study our Evolving Land surface) under cooperative research contract between JAXA and ERI, University of Tokyo. The original ALOS-2/PALSAR-2 data belong to JAXA. We used the RINC developed by Dr. Takeshi Ozawa. We thank Dr. Taku Ozawa for providing RINC to conduct InSAR analysis.

Keywords: Mt. Ontake, precise leveling, Fault model

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Detection ability of Crustal deformation by Slow Slip Events along the Nankai Trough subduction zone

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1. Introduction

Japan Meteorological Agency (JMA) is monitoring data of the strain-meters in the Tokai region installed by the JMA, Shizuoka Prefecture and National Institute of Advanced Industrial Science and Technology (AIST) to detect a crustal deformation induced by a slow slip event along the Nankai Trough subduction zone. On the other hand, JMA cannot monitor the crustal deformation precisely in the western part of the Nankai Trough subduction zone in real time because of few observation stations in the area except for those installed by AIST. National Research Institute for Earth Science and Disaster Resilience (NIED) installed a high sensitive acceleration-meter with a high sensitive seismograph in a Hi-net station throughout Japan. The acceleration-meter can detect small tilt changes induced by slow slips in Nankai Trough subduction zone. Therefore we expect an improved detection ability of crustal variations by an integrated analysis of the high sensitive acceleration-meter data (tilt data) and the strain data. In this study, we investigated the detection ability of the crustal deformation induced by the slow slip applying the Geodetic Data Stacking method (GDS: Miyaoka & Yokota, 2012 and Miyaoka et al., 2017) to tilt data and strain data.

2. Method

Since the tilt and strain data are affected by ambient noise with responses to solid and oceanic tide, atmospheric pressure, geomagnetic field, and precipitation, we firstly correct these responses. Next, we stacked data to enhance signal to noise ratio in order to detect very small crustal deformations caused by slow slip events. In the procedure of data stacking, we calculate a polarity of the deformation by an assumed small slip on the Philippine Sea (PHS) Plate boundary, and stack them with reversing a polarity of the data with negative calculated change. In this research, we assume a 15km x 15km small fault at each grid point of 0.15 degree intervals for latitude and longtitude on the PHS plate and construct an stacked data at each grid point, which would indicate a distinct positive change if a slow slip occur on the corresponding fault. Then we calculated a smallest moment magnitude at all grid points which exceed the three times of noise magnitude.

3. Result

The detectability of crustal deformation due to slow slips on the PHS plate improved especially around the Kii peninsula and the Shikoku region with adding the tilt data of NIED to the stacked data comparing with that using only strain data. In the presentation, we will show a detection ability of the slow slips on the PHS plate in the Nankai Trough subduction zone as well as a spatial resolution of the monitoring with the GDS method.

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Keywords: Slow Slip Event, Geodetic Data Stacking method, Strain-meter data, Tilt-meter data

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An investigation into slow-slip detection capability of the Tokai Strainmenter Network

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We studied the ability of the Tokai Strainmeter Network (hereinafter referred to as TSN) to detect slow slips on a plate boundary where the Nankai trough earthquakes occur. Referring the method of probability-based magnitude of completeness (hereinafter referred to as PMC) that has been applied to several seismic networks (e.g., [1,2,3]), we modified it to be applicable to TSN. While previous studies on slow-slip detection capability of TSN [4] and the network covering a wider region [5] were based on the model assumption that the medium is elastic and the strainmeters record elastic strain changes caused by slow slips, our study is not based on such model assumption, but uses only empirical data: slow-slip catalog, decfiles, and station information. Using slow-slip events with magnitude *M*5.1-5.8 during 2012-2016, we found spatial variability of network detection probability. In general, the detection probability for slow slips of any given *M* is high within the network or inland, whereas it decreases with distance from the coast to offshore. In more details, the detection probability for *M*5.1 in Suruga Bay is above 90%. Although no strainmeter included in TSN has been installed in Suruga Bay, operating strainmeters on land are located so as to surround this Bay. If we consider a large magnitude such as *M* 5.8, slow slips are detectable even in far offshore regions: for example, slow slips with *M*5.8 at the southern edge of the anticipated source region of the Tokai earthquake can be detected with high (>90%) detection probabilities, a consistent result with [5]. We further explored the possible use of our method as a network planning tool with simulation computations of installations of one or more virtual stations to identify appropriate locations for new station installations [2]. Our results show an illustrative example of the applicability of the PMC method to strainmeter networks.
Acknowledgements: This work was partially supported by JSPS KAKENHI Grant Number JP 17K18958.
References: [1] Schorlemmer and Woessner, 2008, Bull. Seism. Soc. Am. 98(5), 2103-2217; [2] Nanjo et al., 2010, Geophys. J. Int. 81(3), 1713-1724; [3] Schorlemmer et al., 2018, Bull. Seism. Soc. Am. 108 (2): 702-717; [4] Kobayashi, 2000, Quart. J. Seism. 63, 17-33; [5] http://www.bousai.go.jp/jishin/nankai/tyosabukai_wg/pdf/h281013shiryo06.pdf.

Keywords: strainmeter network, slow slip, Tokai region

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A Study on Trend Component Estimation Method of Strain Time Series Data Using State Space Model

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When detecting some crustal deformation by strain observation data, it is important to eliminate the influence of barometric pressure, tide and precipitation contained in the observation data and to detect the change of the crustal deformation itself. Usually, by investigating the response due to the effect of barometric pressure or the like in advance and separating from the observation value, the true crustal deformation amount is calculated. Another method is to express the time series data of the crustal deformation observation as a state space model and estimate the distribution of the state vector under the condition given the observation data.

In this study, I express time series of strain data observed by Japan Meteorological Agency as state space model, estimate state vector and some parameters by maximum likelihood estimation with Kalman filter algorithm, and separate trend component. In formulating state space expression, observation values at each time point are divided into trend component, barometric pressure response, tidal response, precipitation response, jump effect like co-seismic step or instrument maintenance, and observation errors. Furthermore, in order to attempt formulation by the state space model of the Ishii type strain meter, the term of the response component to the geomagnetism is introduced and also the jump component is not a simple step function but a posteriori effect (including post-seismic deformation or the relaxation of instruments for sudden strain changes) is expressed.

Compared with the conventional method, by using a state space model approach, it is possible to detect change of trend component more stochastically. As a result, it becomes possible to more objectively judge the start and end of crustal deformation, and it is considered that there is an advantage in inversion of deformation sources based on Bayesian method. If parameters of the state space model can be appropriately estimated based on the accumulated observation data, interpolation of missing values, detection of crustal deformation and estimation of sources can be performed in real time.

Keywords: Strain observation, State space model, Objective detection method of crustal change

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Rainfall correction of strainmeter data in consideration of the flow from the upper reaches (2)

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1. Japan Meteorological Agency, 2. Meteorological Research Institute, Japan Meteorological Agency

Kimura et al. (2015) showed that the flow from the upper reaches was important for the rainfall correction of the strainmeter data at the Tokai-Region. Therefore, Meteorological Research Institute (MRI) started the research by several method about the rainfall correction of the strainmeter in consideration of the flow from the upper reaches (Kimura, 2015).

The Shimada-Kawane station located near the Minari-River is a high possibility that is influenced by the flow from the upper reaches. MRI installed an ultrasonic water gage at the Minari-River examine improvement of the rainfall correction of the strainmeter data at this station. The continuous observation of the river water level was carried out from March 2015 to December 2016.

We tried several ways of using the observation data of this river water level as input values of the tank model directly, but none of them worked. The reason for this is considered to be that the value of the peak of the river water level is too large relative to the amount of precipitation and has a weight and it is difficult to handle it as input data of the tank model like precipitation data.

As another method, we tried using this tank model and precipitation data observed at the Shimada-Kawane station whether this river water level data can be reproduced. As a result, we found that the residual between the observed value and the calculated value is related to the residual of the rainfall correction of the straimeter data. Although no method has been found yet, it is suggested that there is a possibility that the rainfall correction of the straimeter data can be improved from the river water level observation.

Keywords: strainmeter, rainfall correction, the flow from the upper

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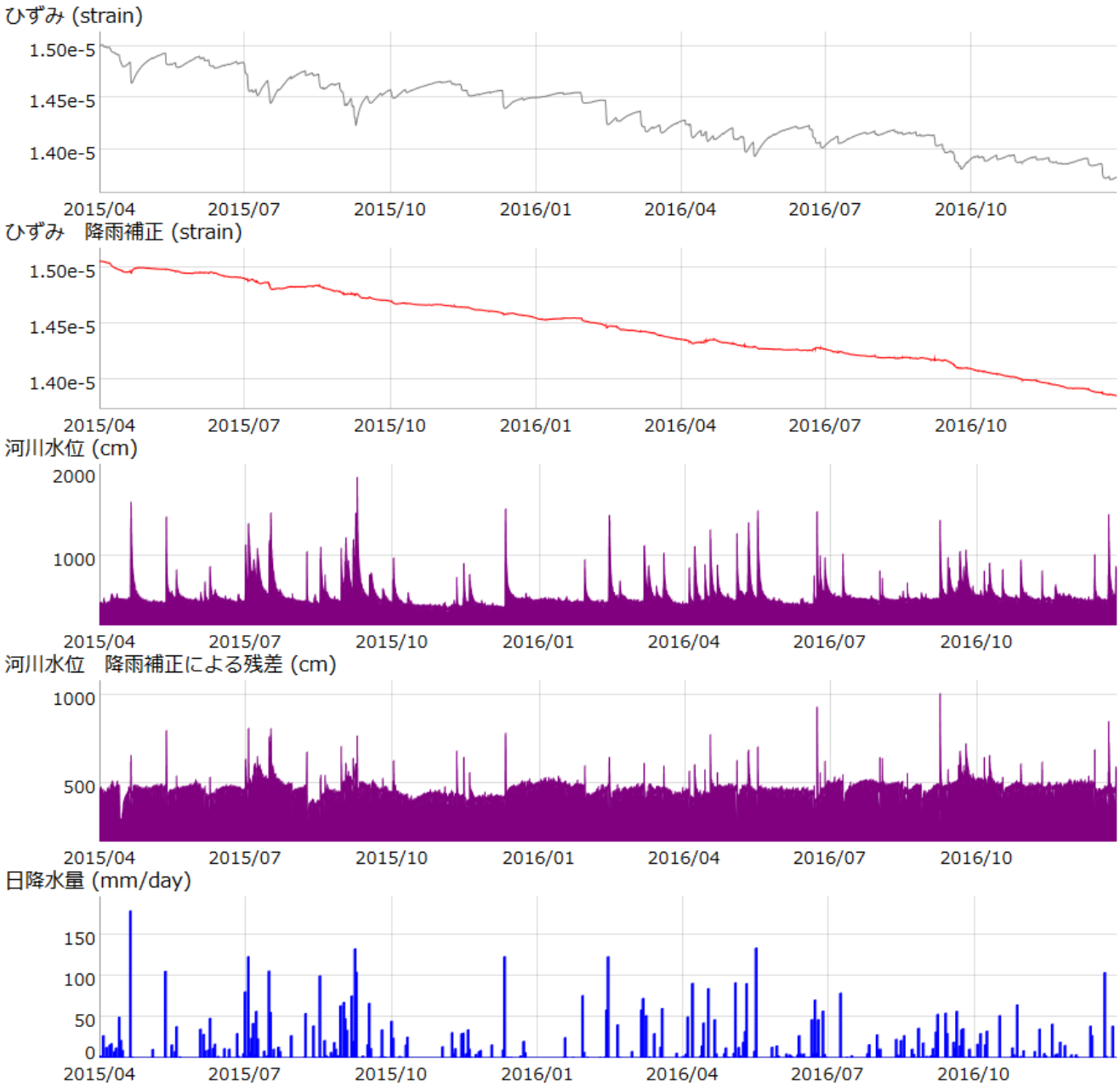

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Long-term slow slip event beneath the Shima Peninsula from 2017 to 2018

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In the Nankai Trough, slow earthquakes such as long-term slow slip events (SSEs) and short-term SSEs have been observed. Long-term SSEs occur around locked fault zones that are considered likely to cause large earthquakes in the future. It is important to characterize the spatiotemporal transitions of long-term SSEs.

We used the daily coordinates of the GEONET F3 analysis operated by the Geospatial Information Authority of Japan. We removed coseismic offsets, artificial offsets, annual and semi-annual variations, and long-term trend. From the displacement from April 2017 to October 2018, the displacement from January 2016 to April 2017 was subtracted for correction of the postseismic deformation. Unsteady displacement in southeast direction about 7-8 mm was seen in the Shima Peninsula.

Assuming that this displacement is due to a long-term SSE, slip distribution on the plate interface was estimated. The estimated slip distribution was located in the Shima Peninsula and moment magnitude was 6.5.

The GNSS F3 coordinate data and offset data were provided by the Geospatial Information Authority of Japan.

Keywords: long-term slow slip event, Shima Peninsula, GNSS

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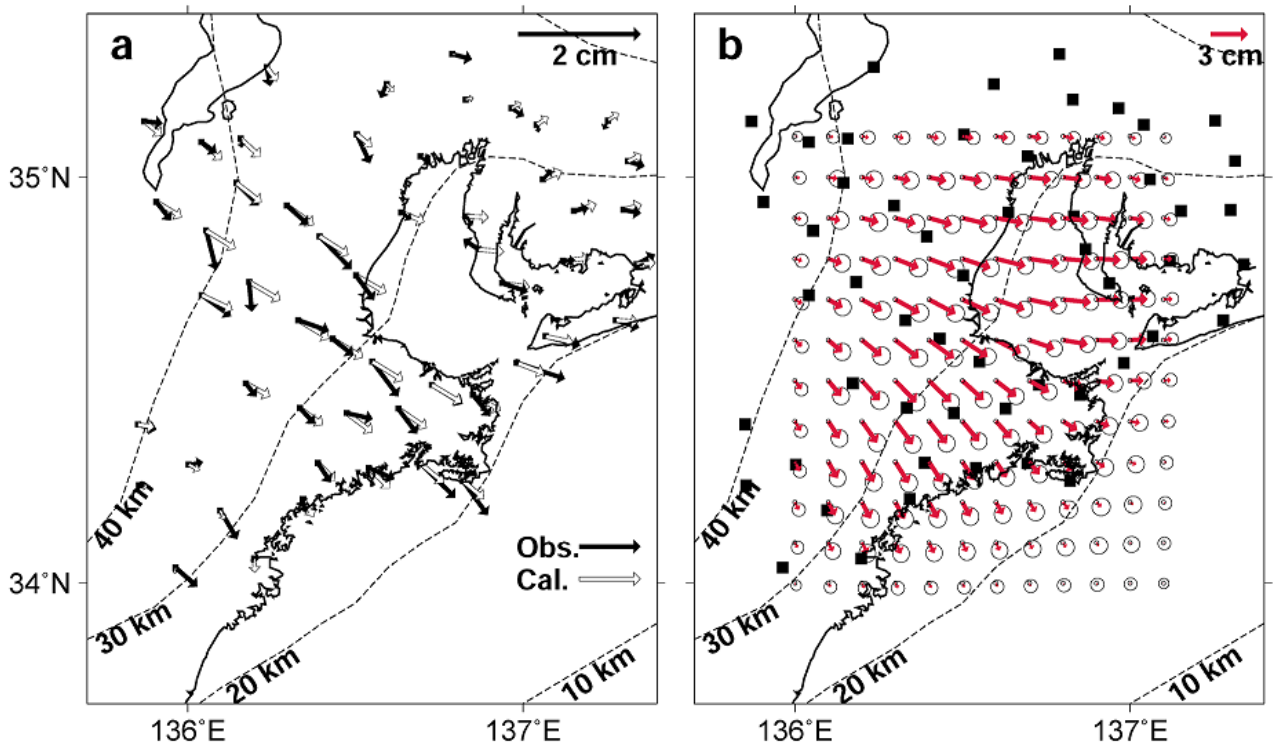

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non- fault slip source components of long-term SSE and the relation to interseismic process preparing for large earthquake generation

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Various types of slow events including slow slip events (SSEs) are detected, and they are explained as fault slip at the plate boundary. However, the mechanism of how to generate a slow event is still open.

From the point of view of the fault strength, source area of slow slip events occurring at the deeper part of the seismogenic zone locate at the brittle-ductile transition zone. The transition from brittle fracture to ductile fracture (or ductile flow) accompany the increase of plastic deformation of rock at the plate interface, and the plastic deformation is not a fault slip at the fault plane but a bulk deformation. If this bulk deformation has an only simple shear component along the plate interface, it is assumed the same as fault slip. On the other hand, if the bulk deformation has the additional mode to the simple shear, the mode is expected to appear as the normal component to the fault plane. Therefore, non-fault slip deformation at the plate boundary, especially normal component, will help to understand the SSE generation mechanism.

Thus our purpose is to detect the non-fault slip deformation at SSE source from observation data, and we select the Tokai long slow slip event (LSSE) because the cumulative Mw is 7.1 and large detectable geodetic signals are expected at GNSS observation points. We examined deformation other than fault slip as Tokai LSSE source by using a finite rectangular fault model with GEONET F3 solution relative displacement in 2001-2003 to 1998-2000 as the reference one. Optimized Tokai LSSE source model of 2yr in 2001-2003 is the finite rectangular fault beneath eastern Aichi Prefecture with 1.6cm tensile dislocation & 9.7cm fault slip, that is, (tensile deformation) : (fault slip) =1:6. This result is better than the case which model has only fault slip component based on AIC (Akaike, 1974).

This result of tensile deformation with fault slip is similar to geological result (e.g., Ujiie et al., 2018). It will help to understand the SSE generation mechanism (e.g., comparing the ratio of tensile dislocation to fault slip). This results depend on the fault geometry; thus source model needs to be reexamined by using realistic plate boundary model along Nankai Trough.

Keywords: slow event, Tokai SSE, generation mechanism, tensile deformation

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Restart of the long-term slow slip events along the Nankai trough after the 2016 Kumamoto earthquake, Japan

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Abstract

Transitional crustal deformation along the Nankai Trough has been observed by GEONET around June 2018. Analysis by time-dependent inversion shows that the long-term SSE occurred in the northern part of Hyuga-Nada Sea from around June 2018 to September and then the slip region moved to the Bungo Channel northeast of 50 km. The sliding area of SSE in 2018 corresponds to the non-slip area of the Hyuga-nada SSE and Bungo channel SSE which were occurring just before the 2016 Kumamoto earthquake. The case of 2018 is a typical example in which long-term SSE was affected by stress perturbation due to a large earthquake, and it gives information on the physical mechanism of SSE. In addition, it has been about 20 years since the last occurrence of the Hyuga-nada earthquake and the probability of the occurrence of the earthquake is 70 to 80% within the next 30 years off the coast of Shikoku. Thus, there is concern about the influence of stress change due to the 2018 SSE on the seismic gap of Hyuga-nada and off the Pacific coast of Shikoku.

Introduction

Along the Nankai Trough, the Hyuga-nada and the Bungo channel long-term SSEs have repeatedly occurred. Long-term SSEs were occurring in Hyuga-nada and Bungo Channel before the 2016 Kumamoto earthquake. Due to the occurrence of the Kumamoto earthquake, SSE in the Hyuga-nada Sea and the Bungo Channel stopped its progress. This is thought to be due to the susceptibility of long-term SSE to stress disturbance caused by a large earthquake. It has been of interest to know when the remaining area of the slip will resume afterwards. Under such circumstances, from around June 2018, transitional crustal deformation was detected by GEONET. The detected transient occurred in northern Kyushu and propagated northeast to the Bungo channel by about 50 km. In this study, we estimated the spatial and temporal evolution of aseismic slip on the plate interface from the observed crustal deformation data by time dependent inversion.

Analytical Method

257 GEONET stations in Shikoku and Kyushu were used in the analysis. From the position time series, the periodic component is estimated from the data of January 2013 to January 2018 and removed from the time series data, after which the linear trend component of January 2017 to January 2018 is removed. The coordinate time series data thus obtained was averaged over 3 days, sampled every 3 days, and used for the time dependent inversion. The analysis period is from January 2018 to January 2019. The weights of east-west, north-south, up-and-down components are set to 5: 5: 1. Hirose et al. (2008) is adopted as a plate boundary model, and it is modeled by a spline surface. The hyperparameters of spatial smoothing and temporal smoothing were estimated by maximum likelihood method.

Result and discussion

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Aseismic slip occurred on the plate interface in the northern part of the Hyuga-nada Sea since around June 2018, subsiding in September. The amount of slippage reaches about 10 cm at the maximum. Since about September, the slip area has moved 50 km to the northeast from the north of Hyuganada to the Bungo Channel. The maximum slippage of the Bungo channel SSE from September 2018 until January 2019 reaches 7 cm. The area slipped at SSE in 2018 corresponds to the area where slip began or did not start in the long-term SSE that occurred until just before the 2016 Kumamoto earthquake. It is thought that reactivation occurred in 2018 two years after the long-term SSE, which stopped due to the stress disturbance accompanying the Kumamoto earthquake in 2016, from the balance between the plate loading and stress relaxation due to viscoelastic deformation. This case is a typical example of stress disturbance to long-term SSE by a large earthquake and very important in understanding the physical process of long-term SSE.

Keywords: slow slip event, Hyuga-nada seas, Bungo channel

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Crustal deformation in the San-in Shear Zone as observed by a dense GNSS network

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1. Disaster Prevention Research Institute, Kyoto University

The San-in Shear Zone (SSZ) is a right-lateral shear zone in southwest Japan with a 30-50 km width, where active seismicity and high strain rates have been observed. No major active fault is identified in the SSZ, however, deformation in the area can be modeled by assuming a 5 mm/yr deep creep on a vertical fault with right lateral motion and conjugate Riedel shears within the shear zone can reconcile the seismotectonics in the area (Nishimura and Takada, 2017). A model having a deep creep on a vertical fault plane well explains observed GNSS velocity, yet it does not provide how wide aseismic motion is confined below a seismogenic depth. Thus, we evaluate the width of the shear zone beneath the SSZ using GNSS data available in the area.

We analyzed daily coordinates from 100 continuous GNSS stations around the SSZ in the postseismic period of the 2011 M_w9.0 Tohoku-oki earthquake (1 January 2014 to 1 April 2018). The network consists of 87 GEONET stations and original stations in the SSZ operated by Kyoto University since 2014 near the source regions the 2000 Western Tottori (M_w6.6) and the 2016 Central Tottori (M_w 6.2) earthquakes. Horizontal displacement rates are calculated for all stations using linear regression with respect to site 0344 (35.09ºN, 134.59ºE). During the analyzed period two major events affected the crustal deformation in the area: the 2016 Kumamoto earthquakes (M_w 7.0) and the 2016 Central Tottori earthquake. Coseismic and postseismic corrections were applied for the perturbed stations. Viscous relaxation associated with the 2011 Tohoku-oki earthquake is expected to affect the SSZ. This effect was removed employing the 3-dimensional viscosity model by Suito (2017).

The SSZ is characterized by strike-slip motion in the N80ºE direction, thus, we focus on deformation in that component. We evaluate deformation along two profiles, one corresponding to eastern Tottori, where the 2000 Western Tottori earthquake took place, and another considering Central and Eastern Tottori. In order to evaluate the width of the shear zone, we assumed multiple vertical faults located every 0.5 km across the region and optimized the slip rate by minimizing the sum of squares residuals. We fixed the depth of the dislocations to 13 km based on microseismicity studies (Omuralieva et al., 2012).

We found the best fitting models with a different width (i.e., 60 km and 21.5 km) for Western and Central-Eastern Tottori, respectively. They suggest that ductile flow in the lower crust is distributed in a channel beneath the SSZ. However, models with a single vertical fault in the middle of the shear zone are also within the confidence interval. GNSS data alone cannot constrain the width of the shear zone in the lower crust.

Keywords: San-in Shear Zone, GNSS data, The 2011 Tohoku-oki earthquake

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Two-dimensional Fourier series representation of surface deformation: Different scales of crustal deformation

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In the Japan islands, located in a plate subduction zone, we often observe two types of crustal deformation overlap with each other: one is elastic deformation due to slip/slip-deficit at plate boundaries and the other is inelastic deformation (brittle fracture and/or plastic flow) in the crust. In order to understand the crustal deformation and its mechanics precisely, we need to appropriately decompose and analyze these different deformations.

The crustal deformation due to slip/slip-deficit at plate boundaries is usually observed as a long-wavelength pattern in the order of 100 km, since the crustal movements are recorded in land-based InSAR and GNSS observation data at some distance from the plate boundaries. In contrast, the inelastic deformation occurs directly beneath the observation networks, and it is observed as a short wavelength pattern in the order of 10 km. Using the different wavelengths of these two types of crustal movements, some studies have already decomposed them. Takada and Fukushima (2013 Nature Geo.) extracted local subsidence caused by the 2011 Tohoku earthquake from InSAR data by subtracting low-pass filtered interferograms as coseismic deformation due to the earthquake rupture. On the other hand, Meneses-Gutierrez and Sagiya (2016 EPSL) and Meneses-Gutierrez et al. (2018 JGR) used a moving average filter to the strain/strain-rate estimated from GNSS data by the method of Shen et al. (1996) and extracted the long-wavelength components as crustal deformation caused by slip/slip-deficit at a plate boundary.

It would be useful to design filters based on the Fourier spectrum for decomposing different scales of surface deformation, since we can flexibly and systematically extract an arbitrary wavelength band of the surface deformation, which varies in according to the size of deformation source or its distance. In this study, we calculated Fourier spectrum of unequally-spaced GNSS displacement data from 2005 to 2011, and extracted arbitrary wavelength bands of crustal deformation. Firstly, we represented the GNSS displacement data as 2-D Fourier series by superposition of trigonometric functions with discrete wavenumbers, and then estimated the Fourier coefficients sequentially in ascending order of the discretized wavenumbers. The estimated coefficients give the Fourier spectrum in the 2-D wavenumber domain. Secondly, using the derivatives of the basis functions (trigonometric functions), horizontal strain distribution was calculated directly from the estimated coefficients. To validate this method, we synthesized test data of a known displacement field using actual spatial distribution of the GNSS observation stations. It was confirmed that the 2-D Fourier spectrum obtained by our sequential analysis method was almost same as that obtained by the discrete Fourier transform using equally-spaced data.

Applying this method to interseismic GNSS displacement rate data in the Kyushu region, we estimated the horizontal strain rate distribution of long wavelength component (wavelength of 200 km or more) and short wavelength component (wavelength of tens to 200 km) from the result of Fourier transform. The long wavelength component showed a similar pattern as the strain rate distribution theoretically calculated from the slip-deficit rate distribution along the Nankai Trough (Noda et al. 2018 JGR). In the short wavelength component, significant strain rates was localized around Beppu-Shimabara Graben and Sakurajima volcanoes.

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Keywords: GNSS, interseismic crustal deformation, Fourier series expansion, strain rates

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GNSS observation around the shear zone in southern Kyushu (The third report)

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1. JAEA, Tono Geoscience Center, 2. JAEA, Horonobe Underground Research Center, 3. Hirosaki University

On the basis of strain rate estimation using GNSS velocities, an active shear zone with high shear strain rate more than 10^{-7}/yr is detected in southern Kyushu. However, obvious active faults in the shear zone are not identified. It is inferred that such high shear strain rate is caused by fault slip in a deep part of the earth’s crust. To investigate the crustal deformation in more detail, we installed 10 GNSS sites across the shear zone from north to south and started observations from March in 2016.
Four GEONET sites operated by Geospatial Information Authority of Japan were fixed as reference sites and daily coordinates from April 18, 2016 to November 24, 2018 were determined, using Bernese GNSS Software (ver.5.2). The time series of site coordinates were corrected by subtracting common mode bias, viscoelastic deformation caused by the 2016 Kumamoto earthquake and volcanic deformation due to Sakurajima and Kirishima volcanoes, from the original time series. Then, site velocities together with annual and semi-annual variations were estimated. As for the data before the 2016 Kumamoto earthquake, we also made corrections in time series of GEONET F3 solutions from October 1, 2007 to March 1, 2009, as processing the data acquired after the earthquake.
In this study, we applied site velocities to a vertical strike-slip fault model proposed by Savage and Burford (1973). This model illustrates that a fault is locked from the surface to a certain depth and is sliding at a uniform velocity which is relative rigid block motion below the locking depth. In this case, the profile of surface deformation normal to the fault strike is expressed as a function of arctangent across the fault. However, using the model, locking depth was estimated to be greater value than average thickness of the earth’s crust. Thus, we considered that the center of the shear zone is located more northern part than current assumed location, which means that two unknown parameters, central shift and fault slope toward the north of the shear zone, are added in the analysis in addition to slip velocity and locking depth.
At first, the initial values of above four unknown parameters were determined using the non-linear least-square method to minimize the residuals between observed and calculated velocities, then those unknown parameters were estimated from the 100,000 times sampling performed by the Metropolis-Hastings algorithm of Markov Chain Monte Carlo methods. On comparison of velocity profiles before and after the earthquake, it resulted that the patterns of those crustal deformation were clearly arctangent form and generally in good agreement with each other within 99% confidence limit, which also indicated that the left-lateral strike slip occurs there. The slip velocity and locking depth were estimated to be 12.4-14.3 mm/yr and 15.6-16.6 km. This shows that steady crustal deformation under the shear zone continues after the earthquakes. Meneses-Gutierrez and Sagiya (2016) investigated strain rate in central-northeastern Japan using GPS data before and after the 2011 Tohoku earthquake and observed inelastic deformation due to long-term EW shortening, which is independent of large earthquakes and continues throughout the whole time periods. The result also suggests that a similar phenomenon occurs at a deep region of the shear zone. Moreover, it suggests a possibility that the center of the shear zone is located about 10 km northward compared with the conventional consideration. While unknown parameters such as fault slope do not have a clear peak of posterior distribution, therefore it is necessary to note that there are large uncertainties in them.

This study was carried out by a contract with the Agency of Natural Resources and Energy, part of the

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Ministry of Economy, Trade and Industry of Japan as part of its R&D program supporting development of technology for geological disposal of high-level radioactive waste.

Keywords: active shear zone in southern Kyushu, GNSS observation, left-lateral strike slip, inelastic deformation, the 2016 Kumamoto earthquake

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Post-seismic deformation of 2016 Kumamoto Earthquake by continuous GNSS network (3)

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1. Department of Earth and Environmental Sciences, Graduate School of Science and Engineering, Kagoshima University, 2. Institute of Seismology and Volcanology, Faculty of Sciences, Kyushu University, 3. Department of Global Environment and Disaster Prevenction, Faculty of Science and Technology, Kochi University,, 4. Kochi Earthquake Observatory, Faculty of Science and Technology ,Kochi University, 5. Aso Volcanological Laboratory, Institute for Geothermal Sciences, Graduate School of Science, Kyoto University, 6. Disaster Prevention Research Institute, Kyoto University, 7. Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University, 8. Disaster Mitigation Research Center, Nagoya University, 9. Earthquake Research Institute, University of Tokyo, 10. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University,, 11. Institute of Seismology and Valcanology, Graduate School of Science, Hokkaido University

GNSS observation is ongoing in Kumamoto district to observe post-seismic deformation of 2016 Kumamoto Earthquake. We set up newly twenty continuous GNSS sites until April 30, 2016. Kyushu Univ., Kyoto Univ. and Kagoshima Univ. operate fifteen continuous GNSS sites before the earthquake. Daily coordinates of these sites are estimated by Bernese GNSS Software Ver. 5.2 with CODE precise orbit. ITRF2014 coordinate system is used. In our daily analysis, GEONET data by GSI and data at continuous GNSS sites in active volcanoes by JMA are also used. A dense continuous GNSS network is constructed.

To emphasize post-seismic deformation, trend at each site is removed. Trend is estimated by least squared method by using between 2004 to 2015. For GNSS sites occupied after the earthquake trend is interpolated by using trend at three neighbor sites.

Post-seismic deformation with large deformation is observed at sites which is located in the eastern side of Hinagu faults. Especially amount of deformation in NS component is large. Largest deformation is 13.5cm in the period from April, 2016 to December 2018 at MIFN. In EW component change in deformation occurred in January 2017. Velocity becomes smaller. In these sites post-seismic deformation is continuous at the moment.

Keywords: GNSS, post-seismic deformation

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[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Masahiko Sato(Department of Earth and Planetary Science, University of Tokyo), Akira Baba(山梨県富士山科学研究所)

We are going to discuss the issues on the magnetic fields of the Earth and planets, paleomagnetism, rock-magnetism, and their applications. This session includes following topics: (1) observation and analysis of the magnetic fields of the Earth and planets, (2) paleomagnetic field variations obtained from natural and archaeological materials, (3) numerical simulations on the magnetic fields of the Earth and planets, (4) measurements and theories of magnetic properties of rocks, minerals, meteorites, and other materials, (5) climate changes and surface tectonics based on the paleomagnetic measurements of rocks and sediments, (6) observations of the magnetic anomalies and the crustal magnetization models of the Earth, planets, and satellites, and (7) developments of the measurement method and data analysis. The presentation and discussion will be made in Japanese or English in this session.
This session contributes toward development of the SEDI-Japan community.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SEM18-01] On the formation process of the Mt.Hoei, Fuji volcano. A scenario based on the emplacement temperature inferred from paleomagnetic method.

*Akira Baba[1], Hidetoshi Shibuya[2], Toshitsugu Fujii[1], Tatsuro Chiba[3] (1.Mount Fuji Research Institute, 2.Department of Earth and Environmental Sciences, Faculty of Advanced Science and Technology, Kumamoto University, 3.Asia Air Survey Co., Ltd.)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SEM18-02] Reconstruction of paleointensity during 5 to 9 th century from Mt. Fuji lavas

Hiromichi Komatsu[2], *Tadahiro Hatakeyama[1,4], Akira Baba[3] (1.Information Processing Center, Okayama University of Science, 2.Faculty of Biosphere-Geosphere Science, Okayama University of Science, 3.Mount Fuji Research Institute, Yamanashi Prefecture, 4.Graduate School of Biosphere-Geosphere Science, Okayama University of Science)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SEM18-03] Reconstruction of full-vector archaeomagnetic reference curve in East Asia from 200 CE to 1100 CE

*Yu Kitahara[1], Daiki Nishiyama[2], Masao Ohno[1], Yuhji Yamamoto[3], Tadahiro Hatakeyama[4] (1.Faculty of Social and Cultural Studies, Kyushu University, 2.Faculty of Science, Kochi University, 3.Center for Advanced Marine Core Research, Kochi University, 4.Information Processing Center, Okayama University of Science)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SEM18-04] A high resolution paleomagnetic record across and around the Matuyama-Brunhes polarity transition from the Chiba composite section

*Makoto Okada[1], Yuki Haneda[2], Yusuke Suganuma[3,4] (1.Department of Earth Sciences, Faculty of Science, Ibaraki University, 2.Graduate School of Scinece and Engineering, Ibaraki Univeristy, 3.National Institute of Polar Research, 4.Graduate University for Advanced Studies)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SEM18-05] Brunhes-Matuyama contact aureole surrounding the Kurobegawa Granite

*Koji Fukuma[1], Hisatoshi Ito[2], Mami Takehara[3], Ryuji Yamada[4], Takashi Kubo[5] (1.Department of Environmental System Science, Faculty of Science and Engineering, Doshisha University, 2.Central

Research Institute of Electric Power Industry, 3.National Institute of Polar Research, 4.National Research Institute for Earth Science and Disaster Prevention, 5.MAIBUNKAN)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SEM18-06] Paleomagnetic study of the IODP Site U1335 sediments in the eastern equatorial Pacific - relative paleointensity and inclination anomaly over the last 8 Myr

*Yuhji Yamamoto[1], Toshitsugu Yamazaki[2] (1.Center for Advanced Marine Core Research, Kochi University, 2.Atmosphere and Ocean Research Institute, University of Tokyo)

On the formation process of the Mt.Hoei, Fuji volcano. A scenario based on the emplacement temperature inferred from paleomagnetic method.

*Akira Baba[1], Hidetoshi Shibuya[2], Toshitsugu Fujii[1], Tatsuro Chiba[3]

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Mt. Hoei (Hoei-san) is located at the southeastern flank of Fuji volcano, and composed mostly of angular rock-fragments which are quite different in petrographic features from the coeval basaltic ejecta of 1707 A.D (Tsuya,1955). It's edifice was formed by a single eruption, the Hoei eruption, according to historical literatures documenting the eruption (e.g. Miyaji and Koyama, 2007). Miyaji et al.,(2011) classified 17 units of the Hoei eruption into 3 stage on the basis of the patterns of the eruptive pulses, and proposed that Mt. Hoei was formed by lateral intrusion of degassed basaltic magma in stage 2. However, detailed geological study of the Mt. Hoei has not been made after Tsuya(1955). Here we report paleomagnetic results of volcanic ejecta of the Mt. Hoei.

Samples for paleomagnetic measurements were collected from 3 sites, the spatter cone in the 1st crater, the ridge of Mt. Hoei and the erosion valley of Gotenniwa. They were oriented by a sun compass to eliminate the influence of local magnetic anomalies. At each site, we collected 20 to 24 samples using an engine powered core picker. Samples were measured using a spinner magnetometer, and were subjected to progressive alternating field (AFD) and thermal demagnetization (ThD).

The mean magnetic directions of each sites show remarkably unanimous. They agree with the eruption age of 1707 A.D., based on similarity to the paleomagnetic secular variation model (JRFM2K.1). The results of ThD indicate that the magnetic minerals are titanomagnetite as the highest blocking temperature is 500-580 degrees C. In the erosion valley of Gotenniwa, the NRM of the accessory materials have high and low temperature components bounded at 340 degrees C or more. It is clear that the low temperature component coincides with the directions of the essential materials of Hoei eruption, so that it was heated by the eruption and cooled after the emplacement. Furthermore, some of the accessory materials in the ridge of Mt. Hoei show magnetic directions different from those of the spatters, so that it was not or weak heated. Mt. Hoei is composed not only abundant various accessory materials but also spatters and pyroclastic deposits of the Hoei basalt which can be corelated to the Ho-Ⅲ tephra (Miyaji et al.,2011) by petrography. Our findings suggest that paleomagnetic method can clarify the simultaneity of volcanic ejecta, and the Mt. Hoei was rapidly formed by ultraproximal fall or surge deposits of the Hoei eruption in 1707 A.D.

Keywords: Fuji volcano, Mt.Hoei, paleomagnetic method

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Reconstruction of paleointensity during 5 to 9 th century from Mt. Fuji lavas

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The origin of the Earth's magnetic field is due to the electromagnetic fluid motion in the Earth' core by self-exciting dynamo. Therefore, the geomagnetic field varies each place, and it is changing over time. Observation of the changing geomagnetic field in each place is indispensable for the development of the global geomagnetic field model.

In Japan, measurements of paleointensity since the dawn of history are made using archeological materials that is well known age. On the other hand, in this study, we measured the paleointensity of the samples taken from 16 sites of basaltic lava flows showing the secular variation of geomagnetic field direction in the 5th - 9th century erupted from Mt. Fuji where geologic stratigraphy was described in more detail in recent years. The obtained paleointensity was compared with the archaeo- and paleointensity measured by the old methods and with the recent archeointensity work derived from the floor surface of the old kiln.

In this study, we used the latest, Tsunakawa-Shaw method (Tsunakawa and Shaw, 1994). We obtained successful results from 39 specimens out of 62 specimens taken from 16 sites, and we could calculate the mean and variance from 9 sites where more than 3 acceptable samples were obtained. From these results, it was concluded that the basaltic lavas from Mt. Fuji is suitable to restore the paleointensity.

Many of the old works done in the last century using old methods(Thellier and Thellier, 1959) indicated high paleointensity around 60 μT in this time window, while, paleointensity by modern methods, IZZI Thellier method (Tauxe and Studigel, 2004) and Tsunakawa-Shaw method, indicated lower values of intensities (Kitahara, 2018). The palaeointensities obtained in this study are consistent with the latter with similar trends of the field fluctuation. In addition, the results of this study inter- and extrapolated the paleointensity of the age of the recent work and the geomagnetic field variation in Japan becomes clear.

Keywords: Paleointensity, Mt. Fuji

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Reconstruction of full-vector archaeomagnetic reference curve in East Asia from 200 CE to 1100 CE

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Paleomagnetic information reconstructed from archaeological materials is used to estimate the archaeological age of excavated relics, in addition to revealing the geomagnetic secular variation and core dynamics. The direction and intensity of the Earth’ s magnetic field (archaeodirection and archaeointensity) have been estimated using different methods, many of which have been proposed over the past decades. Among them a new experimental technique for archaeointensity estimate is the Tsunakawa-Shaw method.

This study carried out the reconstruction of the archaeointensity using the Tsunakawa-Shaw method for a large number of samples of baked clay belonging to different ages from archaeological relics in Osaka Prefecture mainly, and constructs a dataset and the reference curve of archaeointensity in Japan (East Asia).

As the result, we estimated archaeointensities from 98 specimens belonging to 39 relics. We screened these data, compiled them for each pottery sequence, and finally obtained 10 mean intensity values of the pottery sequence level. All of the mean intensity values satisfy the selection criteria, which indicates that they have sufficient reliability. It is notable that these newly estimated archaeointensity values are lower than those in previous studies in Japan. On the other hand, new archaeointensity values show a harmonic trend in the archaeointensity data set obtained by the IZZI-Thellier method reported recently in Korea. We combined the dataset of Japan newly obtained in this study and the dataset in Korea, and drew an interpolation curve to construct an archaeointensity reference curve covering from around 200 CE to around 1100 CE in East Asia. This reference curve includes events of decrease and increase of archaeointensity occurred at around 600 CE and around 950 CE. The trends of rapid decrease and increase in intensity are a characteristic pattern of the intensity variation found for the first time in this study.

Keywords: Archaeointensity, Reference curve, East Asia, Tsunakawa-Shaw method, Old kiln

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A high resolution paleomagnetic record across and around the Matuyama-Brunhes polarity transition from the Chiba composite section

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1. Department of Earth Sciences, Faculty of Science, Ibaraki University, 2. Graduate School of Scinece and Engineering, Ibaraki Univeristy, 3. National Institute of Polar Research, 4. Graduate University for Advanced Studies

We report a high-resolution paleomagnetic direction and relative paleointensity records from a continuous marine succession, consisting of 80 meters in thickness, exposed on the Chiba composite section of the Kokumoto Formation, Kazusa Group, Japan. The Chiba composite section is a candidate for the Lower-Middle Pleistocene boundary GSSP. Our records provide detailed behaviors of the virtual geomagnetic poles (VGPs) and relative paleointensity changes during and after the Matuyama-Brunhes (M-B) polarity transition. The resultant relative paleointensity and VGP records show a significant paleointensity minimum near the M-B boundary, which is accompanied by a clear “polarity switch” like change in terms of the paleomagnetic direction. The relative paleointensity seems to keep in a low level for more than 10 thousand years associated with an unstable normal polarity. A high-resolution oxygen isotope chronology for the Chiba composite section indicates that the M-B boundary is located in the middle of Marine Isotope Stage (MIS) 19 and yields an age of 772.9 ka for the boundary. This age is consistent with those based on the latest astronomically tuned marine and ice core records and with the recalculated age of 771.7 ±7.3 ka deduced from the U-Pb zircon age of the Byk-E tephra. Moreover, our relative paleointensity record exhibits a consistent variation with other paleointensity records including Be10 derived intensity proxy from deep sea and ice cores. Our paleomagnetic data especially for the relative paleointensity represent one of the most detailed records on this geomagnetic field reversal so far obtained from marine sediments and will therefore be key for understanding the dynamics of the geomagnetic dynamo and for calibrating the geological time scale.

Keywords: Chiba Composite Section, Matuyama-Brunhes boundary

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Brunhes-Matuyama contact aureole surrounding the Kurobegawa Granite

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Contact test is most powerful paleomagnetic field test to give tight constraints on the timing of magnetization acquisition for both country and intrusive rocks. Especially when the country rock is normally magnetized and later thermally metamorphosed during a reversed polarity chron and vice versa, totally or partially remagnetized zones in the country rock can be unequivocally identified as a function of distance from the contact. Here we show an example of contact test for a youngest pair of country and intrusive rocks emplaced during the Matuyama and Brunhes chron respectively. The Quaternary Kurobegawa Granite, which is the youngest granite with U-Pb ages of about 0.8 Ma, forms a volcanic-plutonic complex with the Jiigatake Volcanic Rocks dated about 1.6 Ma by several geochronological methods. Paleomagnetic analyses including contact test for the volcanic-plutonic complex contribute to elucidate the emplacement and deformation processes related to the building of the Hide Mountains. We collected oriented blocks at 14 sites of the Kurobegawa Granite and 6 sites of the Jiigatake Volcanic Rocks. As we expected multidomain grains carry significant portions of natural remanent magnetization, we applied low temperature demagnetization with liquid nitrogen and then performed thermal demagnetization at every 25 degC step from room temperature up to 600 degC with the automated magnetometer-demagnetizer system Tspin. Low temperature demagnetization effectively erased 10-75% of initial magnetization and the middle to high temperature characteristic remanent magnetizations were retrieved at most sites except for some samples struck by lightning. Characteristic remanence directions from a single site are well clustered and the site-mean directions are of normal polarity without exception for the Kurobegawa Granite. The primary magnetizations postdated the age ~0.8 Ma of U-Pb geochronology of a closure temperature 900 degC and are presumed to be acquired during the Brunhes chron (< 0.77 Ma). In the contact aureole of the Jiigatake Volcanic Rocks metamorphosed by the Kurobegawa Granite, we found one totally remagnetized normal-polarity site and two partially remagnetized sites having hybrid normal and reversed magnetizations. This positive contact test suggests that the characteristic magnetization of the Kurobegawa Granite is not of recent viscous origin although the direction is not distinguishable from that of the present geomagnetic field. Neither large-scale tilting nor deformation was found out from the site-mean directions of the Kurobegawa Granite.

Keywords: contact test, granite, low temperature demagnetization, tectonics

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Paleomagnetic study of the IODP Site U1335 sediments in the eastern equatorial Pacific - relative paleointensity and inclination anomaly over the last 8 Myr

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Obtaining continuous records of relative paleointensity (RPI) and inclination anomaly (ΔI) is inevitable to understand the fundamentals of the geodynamo, but available records older than ~3 Ma are still very limited in time and space. We performed a paleomagnetic study of the Integrated Ocean Drilling Program (IODP) Site U1335 sediments in the eastern equatorial Pacific to obtain continuous RPI and ΔI records since ~8 Ma. Slow deposition, ~8.4 m/Myr or less, limits the resolution of the records but did allow for determination of long-term variations. Rock-magnetic measurements showed that biogenic magnetite dominates the magnetic mineral assemblages, and the proportion of biogenic to terrigenous magnetic minerals increases prior to ~4 Ma. The average paleointensity between ~4 and 8 Ma is approximately 30% lower than that from 0 to ~4 Ma. The apparent reduction of RPI at ~4 Ma reaches approximately ~50%, but ~20% of this is estimated to be artificial, induced by the increase in the proportion of biogenic magnetite. No relation between paleointensity and polarity length is recognized for the last ~8 Myr. The magnitude of ΔI is slightly larger during reversed polarity chrons (4.43° ±1.47°) than normal polarity chrons (0.69° ± 2.98°) over the last ~5 Myr, which agrees with the available TAF models of this time span. Prior to ~6 Ma, the sign of ΔI during the normal chrons might have switched to positive, and ΔI during reversed chrons might have been slightly larger than that after ~5 Ma.

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[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Yu Kitahara(Graduate School of Social and Cultual Studies, Kyushu University), Hisayoshi Shimizu(The University of Tokyo)

We are going to discuss the issues on the magnetic fields of the Earth and planets, paleomagnetism, rock-magnetism, and their applications. This session includes following topics: (1) observation and analysis of the magnetic fields of the Earth and planets, (2) paleomagnetic field variations obtained from natural and archaeological materials, (3) numerical simulations on the magnetic fields of the Earth and planets, (4) measurements and theories of magnetic properties of rocks, minerals, meteorites, and other materials, (5) climate changes and surface tectonics based on the paleomagnetic measurements of rocks and sediments, (6) observations of the magnetic anomalies and the crustal magnetization models of the Earth, planets, and satellites, and (7) developments of the measurement method and data analysis. The presentation and discussion will be made in Japanese or English in this session.
This session contributes toward development of the SEDI-Japan community.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SEM18-07] Sensor Response Estimate and Calibration of Superconducting Rock Magnetometers

*Hirokuni Oda[1], Chuang Xuan[2] (1.Institute of Geology and Geoinformation, Geological Survey of Japan, AIST, 2.University of Southampton)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SEM18-08] Magnetic separation of ordinary solid particles using a pokcet size magnetic circuit

*Chiaki Uyeda[1] (1.Institute of earth and Space Science Graduate School of Science Osaka University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SEM18-09] Experimental evaluation of remanence carriers in coercivity-blocking temperature diagram

*Masahiko Sato[1], Takuma Terada[2], Nobutatsu Mochizuki[3], Ayako Ito[2], Hideo Tsunakawa[2] (1.The University of Tokyo, 2.Tokyo Institute of Technology, 3.Kumamoto University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SEM18-10] **Mineralogical study on magnetite exsolution and host plagioclase crystal**

*Yujiro Tamura[1], Ryoichi Nakada[2], Masahiko Sato[3], Shinji Yamamoto[4] (1.Graduate schoole of Environment and Information Sciences, Departmennt of Natural Environment, Yokohama National University, 2.Kochi Institute of Core Sample Reserch, Japan Agency for Marine-Earth Science and Technology, 3.Department of Earth and Planetary Science, The University of Tokyo, 4.Graduate schoole of Environment and Information Sciences, Yokohama National University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SEM18-11] Numerous nano-sized magnetite and hematite inclusions in muscovite in loess

*Masayuki Hyodo[1], Takuro Sano[2], Megumi Matsumoto[3], Yusuke Seto[2], Kota Suzuki[2], Tianshui Yang[4] (1.Research Center for Inland Seas, Kobe University, 2.Graduate School of Science, Kobe University, 3.Graduate School of Science, Tohoku University, 4.China University of Geosciences)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SEM18-12] Density separation and magnetic measurements of magnetotactic bacteria *Magnetospirillum magnetotacticum* MS-1

*Kohei Masaoka[1], Yuki Morono[2], Naotaka Tomioka[2], Go-Ichiro Uramoto[1], Yuhji Yamamoto[1] (1.Kochi University, 2.Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology)

Sensor Response Estimate and Calibration of Superconducting Rock Magnetometers

*Hirokuni Oda[1], Chuang Xuan[2]

1. Institute of Geology and Geoinformation, Geological Survey of Japan, AIST, 2. University of Southampton

Pass-through superconducting rock magnetometers (SRM) offer rapid and high-precision remanence measurements for continuous sediment samples that are essential for modern researches on paleomagnetism and environmental magnetism. However, continuous SRM measurements are smoothed and distorted due to the convolution effect of SRM sensor response. Thus, deconvolution is necessary to restore accurate magnetization from pass-through SRM data, and robust deconvolution requires reliable estimate of SRM sensor response. In the presentation, we present a new software tool ‘uresponse’ developed for the purpose of evaluation and optimization of SRM sensor response. The example sensor responses were acquired for two SRMs at University of Southampton; i.e. liquid He-operated (old) and liquid He-free (new) ones. Precise point source held in the center of 5×5×5mm plastic cube was used for the measurement with a magnetization pointing to one of the faces together with a gridded measurement block. With the software, each tensor components of sensor response for magnetization in X-, Y-, Z-axes to a pick-up coil in X-, Y-, and Z-axes acquired for the measurement grids are smoothed, interpolated and integrated over the cross-sectional area of a measured u-channel sample. In addition, absolute magnetization of the point source was estimated by cross calibration with a palladium standard using MPMS at National Institute of Advanced Industrial Science and Technology. By comparing repeated measurements of a u-channel sample containing geomagnetic reversal on the two SRMs before and after deconvolution, we demonstrate the significant differences in measurements caused by different sensor responses of the two types of magnetometers, and show how deconvolution with well-constrained response functions can help to largely overcome the convolution effects and distortion for measurements on both SRMs.

Keywords: SQUID Rock magnetometer, Deconvolution, sensor response curves

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Magnetic separation of ordinary solid particles using a pokcet size magnetic circuit

*Chiaki Uyeda[1]

1. Institute of earth and Space Science Graduate School of Science Osaka University

An ensemble of heterogeneous solid particles, composed namely of bismuth, enstatite (Myanmar), olivine (San Carlos), gold and graphite, are separated into fractions of different materials by small magnetic circuit composed of two NdFeB plates (4.0×4.0×1.0cm).[1] The abovementioned separation & identification followed a recently-reported principle [2][3] that acceleration of a particle, induced by magnetic volume force in an area of field gradient, is uniquely determined by intrinsic susceptibility of material, and its acceleration was independent to mass of particle. The small magnetic circuit produced a field distribution that monotonically decreased along a x-axis that was located between the two plates (0.4 cm in width [1]. The mixture of the particles was maintained at the bottom of a half-piped scape (0.2 cm in depth). An orifice (diameter: 0.07 cm) was located at the bottom of the halfpipe, which was set just above the circuit gap. An area with a height of 4cm was located below the circuit, and a cross-sectional paper was horizontally set at the bottom of this area to collect the translating particles. The horizontal separation, *x*, of the individual particles with respect to the position of the orifice were measured after they were collected on the plate. The particles were manually pushed towards the orifice position one by one using a thin copper wire and were dropped from the orifice with small initial velocity. Among the separated materials, graphite is known to have the smallest diamagnetic susceptibility of popular materials; whereas, the paramagnetic susceptibility observed in many of the rock forming minerals are smaller than that of San Carlos Olivine. Accordingly, the susceptibilities reported for the most existing materials in nature overlap with the values of the abovementioned five materials.

The efficiency of the proposed material separation is improved by increasing the variance of horizontal velocity between the two particles, because it directly increases the separation of the particles observed on collecting plate. The velocity can be enhanced by increasing the field-gradient of the magnetic circuit. A circuit having a compact size suitable for on-site researches (edge length: ~10 cm, weight: ~1.5 x10^3g) was previously designed and developed. The field gradient produced by the circuit was as large as 6250 G/cm, which could increase the field-induced velocity of particle by an order of magnitude.

It is presently considered that most solid particles, composed of diamagnetic or weak paramagnetic materials, are magnetically inert; the conventional magnetic separators were not used to extract these materials. Hence the new method proposed in the present study may extend to an effective technique of pre-treatment in analysing aggregates, because such technique is desired in various research fields of science; it may play a role of a “chromatography technique” conventionally used in the analysis of organic molecules. The portable and low-cost system may provide a breakthrough for on-site research in industrial and medical fields as well as in resource explorations in nature.

[1] Uyeda, Terada, Hisayoshi, (2019) Sci., Reps., *in print.*

[2] Hisayoshi, Uyeda & Terada (2016) Sci., Reps., 6, 38431.

[3] Yamaguchi, Hisayoshi, Uyeda & Terada (2017) J. Phys., Conf. Ser.903, 012026.

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Keywords: magnetic separation, diamagnetic material, paramagnetic material

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Experimental evaluation of remanence carriers in coercivity-blocking temperature diagram

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1. The University of Tokyo, 2. Tokyo Institute of Technology, 3. Kumamoto University

Knowledge of the remanence carrier in recording media is crucial for obtaining reliable paleomagnetic data. Here we report newly developed technique to evaluate the remanence carrier of natural rock samples using anhysteretic remanent magnetization (ARM) spectra in coercivity (H_c) and blocking temperature (T_B) plane (hereafter referred to as H_c-$T_B$diagram). Experimental procedures are as follows: (1) imparting ARM at 50 μT DC field and 140 mT AC field, (2) thermal demagnetization (THD) for the ARM at a certain temperature, (3) stepwise alternating field demagnetization (AFD) for the remaining ARM, (4) repeating steps 1–3 with THD treatment at a higher temperature, and (5) calculating second derivative of ARM on the H_c-$T_B$plane. Samples from three basaltic lavas and two welded tuffs were used for H_c-T_B diagram experiments. The basaltic lava samples consist of HW95 from Hawaiian 1995 lava flow of pahoehoe, OS86 from Izu-Oshima 1986 lava flow at the northwest flank of Mihara Volcano (Japan), and UN01 from Kiso-ontake lava flow (called Ueno basaltic rocks) in Nagano (Japan), which extruded during the Matuyama chron. The welded tuff samples were KM01 from Komagatake welded tuff and SK03 from Shikotsu welded tuff, both of which extruded 30-35 ka in Japan. In the cases of HW95, UN01, and KM01 samples, remanence carriers are composed mainly of a single phase in the H_c-$T_B$diagram. The OS86 sample showed two phases in the H_c-$T_B$diagram which can be distinguished from each other by AFD treatment but not THD treatment because of similar $T_B$spectra. In the case of SK03 sample, second derivatives of ARM showed not only positive values but also negative values in the H_c-$T_B$diagram. The negative value implies significant effects of thermal alteration due to laboratory heating. On the basis of H_c -$T_B$diagrams, we will further discuss remanence carriers in the measured samples.

Keywords: Anhysteretic remanent magnetization, Coercivity, Blocking temperature, Paleointensity

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Mineralogical study on magnetite exsolution and host plagioclase crystal

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Since natural plagioclase crystal sometimes contains fine-grained magnetite as an exsolution lamellae, single plagioclase crystals are used for recent paleointensity study (e.g. Kato et al., 2018). Especially, plagioclase in plutonic rocks can record average paleointensity due to their long cooling time scale (Tunakawa et al., 2009). However, such magnetite esxolution in plagioclase does not always observed in plutonic rocks. Moreover, magnetite exsolution in plagioclase sometime shows heterogeneous distribution in each plagioclase crystals. Because maximum solubility in plagioclase decreases during cooling, magnetite lamellae formation is restricted by chemical composition of whole rock and plagioclase. Furthermore, its formation is restricted by valence state of iron in each crystal, because divalent and trivalent iron are required for magnetite crystallization.

The sample investigated in this study was collected from the Doshi gabbro, northwest of Tanzawa tonalitic complex. Plagioclase crystals in the gabbro show that magnetite lamellae exsolve along oscillatory zoning in plagioclase. To describe fine exsolution lamellae, thin sections with double-side polished were made. Afterward we observed the sample by polarizing microscope and electron microscope and analyzed composition of plagioclase by Electron-Probe-Micro-Analyzer. We obtained high resolution X-ray fluorescence mapping of Fe and Ca followed by Fe K-edge X-ray absorption near-edge structure (XANES) analysis at the BL37XU of SPring-8.

In polarizing microscope observation, magnetite exsolutions with grain size up to a few microns show parallel orientations and most of them appear prolate spheroid morphology. In element mapping of Ca, plagioclase crystals have multiple oscillatory zonations and magnetites are exsolved at the area of lower anorthite content. Distribution of iron in plagioclase is almost uniform except for the rim. In XANES analysis, valence state of iron in plagioclase vary in from 2.47 to 2.55, and correlated with anorthite content.

Oscillatory zoning of plagioclase generally reflects their crystallization process, and anorthite rich plagioclase is usually crystallized in the early stage of crystallization. It is known that trivalent iron is easier to be distributed to plagioclase than divalent iron form melt (Lundgaard & Tegner 2004). According to the correlation between anorthite content and valence state of iron, trivalent iron is distributed to higher anorthite content area. In other words, during a process of plagioclase crystallization, divalent iron is distributed to lower anorthite content area. In another aspect, partition coefficient of iron to plagioclase depends on oxygen fugacity in magma chamber. Mineralogical features of magnetite exsolution and host plagioclase crystal suggest that there are multiple origins of the magnetite exsolutions in plagioclase even in single crystal.

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Keywords: Magnetite exsolution, Plagioclase

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Numerous nano-sized magnetite and hematite inclusions in muscovite in loess

*Masayuki Hyodo[1], Takuro Sano[2], Megumi Matsumoto[3], Yusuke Seto[2], Kota Suzuki[2], Tianshui Yang[4]

1. Research Center for Inland Seas, Kobe University, 2. Graduate School of Science, Kobe University, 3. Graduate School of Science, Tohoku University, 4. China University of Geosciences

Magnetic enhancement of Chinese loess–paleosol sequences has been used extensively as a proxy for the East Asian summer monsoon. This magnetic enhancement occurs due to neoformation of pedogenic ferrimagnets. However, these ferrimagnets are difficult to extract; consequently, how they are formed is not well understood. Here, we show the shape of the crystals and the presence of nano-sized pedogenic magnetic particles using electron microscopy, a synchrotron radiation X-ray diffraction technique, and rock magnetic methods. The magnetic particles comprise pedogenic magnetites, detrital magnetites with maghemite shells, and detrital/pedogenic hematites. Among the fraction samples, the medium grain-size (1–10 μm) fraction was responsible for most of the magnetic enhancement of the paleosols. Magnetic extraction experiments revealed that muscovites and chlorites in the paleosol samples showed weak spontaneous magnetization. In the medium grain-size paleosol fraction, we found a weathered muscovite grain that included many hundreds of nanometer-sized magnetite and hematite particles in aggregates with biotites, which are Fe-bearing silicates. There were similar aggregates surrounding muscovite and chlorite fragments. The concentration of pedogenic magnetite/hematite inclusions was much higher in this muscovite grain than in the submicron-sized iron oxides found on the silicate surfaces. The nano-sized magnetite/hematite inclusions must be responsible for the weak spontaneous magnetization of the muscovites and chlorites, significantly contributing to the magnetic enhancement of the mature paleosols. These magnetite inclusions are mainly responsible for the paleosol pseudo-single-domain magnetic properties extensively observed across the Chinese Loess Plateau. The protective silicates account for the low extraction efficiency and the near absence of oxidation by surrounding air.

Keywords: loess magnetism, pedogenic magnetic particles, TEM, SEM, Synchrotron radiation x-ray diffraction, weathering

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Density separation and magnetic measurements of magnetotactic bacteria *Magnetospirillum magnetotacticum* MS-1

*Kohei Masaoka[1], Yuki Morono[2], Naotaka Tomioka[2], Go-Ichiro Uramoto[1], Yuhji Yamamoto[1]

1. Kochi University, 2. Kochi Institute for Core Sample Research, Japan Agency for Marine-Earth Science and Technology

Variation of the past geomagnetic field is recorded in marine sediments as a fossil magnetization, called natural remanent magnetization (NRM). NRM is carried not only by detrital and eaolian magnetic grains but also by biogenic magnetic grains originated from magnetotactic bacteria. To investigate characters of NRM carried by biogenic magnetic grains we have cultured the microaerobic bacteria *Magnetospirillum magnetotacticum* MS-1 (here under, MS-1) in laboratory and made sample using them for remanent magnetization measurements by simulating a very early process of sediment formation.

Preliminary reports on properties and characters of the remanent magnetization carried by the samples have been presented in Masaoka et al (2018JpGU; 2018SGEPSS), but MS-1 cells used for making samples rarely contain magnetite grains in these cells (3 percent of the total cells). To try to increase number of the cells containing magnetite grains, we have tested a density separation method using different density gradient centrifugation and made samples for magnetic measurements using these cells. We will report these results including observations under transmission electron microscope.

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[J] Oral | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | A08 TOKYO BAY MAKUHARI HALL

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo), Chairperson:Masahiko Sato(Department of Earth and Planetary Science, University of Tokyo), Hisayoshi Shimizu(The University of Tokyo)

We are going to discuss the issues on the magnetic fields of the Earth and planets, paleomagnetism, rock-magnetism, and their applications. This session includes following topics: (1) observation and analysis of the magnetic fields of the Earth and planets, (2) paleomagnetic field variations obtained from natural and archaeological materials, (3) numerical simulations on the magnetic fields of the Earth and planets, (4) measurements and theories of magnetic properties of rocks, minerals, meteorites, and other materials, (5) climate changes and surface tectonics based on the paleomagnetic measurements of rocks and sediments, (6) observations of the magnetic anomalies and the crustal magnetization models of the Earth, planets, and satellites, and (7) developments of the measurement method and data analysis. The presentation and discussion will be made in Japanese or English in this session.
This session contributes toward development of the SEDI-Japan community.

1:45 PM - 2:05 PM JST | 4:45 AM - 5:05 AM UTC

[SEM18-13] Effects of the intrinsic magnetic field on the atmospheric escape from terrestrial planets

★Invited Papers

*Kanako Seki[1], Shotaro Sakai[1], Shogo Inui[1], Ryoya Sakata[1], Naoki Terada[2], Hiroyuki Shinagawa[3], David A. Brain[4] (1.Graduate School of Science, University of Tokyo, 2.Graduate School of Science, Tohoku University, 3.NICT, 4.LASP, University of Colorado, Boulder)

2:05 PM - 2:20 PM JST | 5:05 AM - 5:20 AM UTC

[SEM18-14] Numerical modeling of a lunar dynamo and its long-term evolution

*Fumi Hyodo[1], Futoshi Takahashi[2], Satoshi Kaneshima[2], Hisayoshi Shimizu[3], Hideo Tsunakawa[4] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, Kyushu University, 3.Earthquake Research Institute, University of Tokyo, 4.Deparment of Earth and Planetary Sciences, Tokyo Institute of Technology)

2:20 PM - 2:40 PM JST | 5:20 AM - 5:40 AM UTC

[SEM18-15] Investigation of sub-grid scale (SGS) model in dynamo simulations with small Ekman and magnetic Prandtl numbers

★Invited Papers

*Hiroaki Matsui[1] (1.Dept. of Earth and Planetary Sciences, University of California, Davis)

2:40 PM - 2:45 PM JST | 5:40 AM - 5:45 AM UTC

Discussion

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SEM18-16] Growth rates of kinematic dynamos in a finite domain

*Ataru Sakuraba[1] (1.Department of Earth and Planetary Science, University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SEM18-17] Detection of jerk-like magnetic field variation in a numerical dynamo model using wavelet analysis

*Futoshi Takahashi[1], Yoshiki Manabe[2] (1.Faculty of Sciences, Kyushu University, 2.Department of Earth and Planetary Sciences, Kyushu University)

Effects of the intrinsic magnetic field on the atmospheric escape from terrestrial planets

*Kanako Seki[1], Shotaro Sakai[1], Shogo Inui[1], Ryoya Sakata[1], Naoki Terada[2], Hiroyuki Shinagawa[3], David A. Brain[4]

1. Graduate School of Science, University of Tokyo, 2. Graduate School of Science, Tohoku University, 3. NICT, 4. LASP, University of Colorado, Boulder

Mechanisms of atmosphere escape from Mars to space is one of important problems to understand drastic climate change in the ancient Mars. The geological studies suggest that the climate change occurred from 4 to 3.5 billion years (Ga) ago. It is known that the time period interestingly corresponds to the period just after the ancient Mars lost its global intrinsic field between 4 and 4.1 Ga ago. Observations by NASA's Mars Atmosphere and Volatile EvolutioN (MAVEN) have provided new insights about the atmospheric escape processes in operation at Mars. Among them, the cold ion escape is a promising candidate to enable a large number of heavy ions to escape from the ionosphere. In this study, we present an overview of the results of a statistical analysis of the ion composition measurements by MAVEN as well as global multi-species MHD simulations of solar wind-Mars interactions with a focus in effects of the intrinsic magnetic field. Based on these results, we will discuss the effects of the intrinsic magnetic field on the atmospheric escape from terrestrial planets.

Keywords: intrinsic magnetic field, Mars, Atmospheric escape, climate change, ion outflow, multi-species MHD simulation

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Numerical modeling of a lunar dynamo and its long-term evolution

*Fumi Hyodo[1], Futoshi Takahashi[2], Satoshi Kaneshima[2], Hisayoshi Shimizu[3], Hideo Tsunakawa[4]

1. Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2. Department of Earth and Planetary Sciences, Kyushu University, 3. Earthquake Research Institute, University of Tokyo, 4. Deparment of Earth and Planetary Sciences, Tokyo Institute of Technology

Now the Moon has no global magnetic field unlike the Earth, and there are only local crustal fields which are of approximately several hundred nT on the lunar surface [Tsunakawa et al., 2015]. However, lunar paleomagnetic studies indicate evidence for ancient lunar dynamo, and that the Moon had a global magnetic field of about 70 μT on the lunar surface at least between 4.2 and 3.56 Ga [e.g., Garrick-Bethell et al. 2009; Shea et al., 2012; Suavet et al., 2013]. In this study, we assume that the lunar dynamo is powered by compositional buoyancy due to inner core growth, which enabled the dynamo to work for such a long time interval. Based on the assumption, we perform a series of numerical simulations of MHD dynamo by varying the ratio of the inner core and outer core radii $\chi = r_i/r_o$ from *0.1* to 0.7 like Heimpel et al. [2005], where r_i and r_o are the inner core radius and the outer core radius, respectively. Long-term variations of the Rayleigh number *Ra* and the Ekman number *E*, which are key dimensionless parameters controlling the dynamo action, used in the dynamo simulations are calculated as functions of χ from a thermal history model of the lunar core. Then a relative core evolution curve is drawn, along which we perform a suite of dynamo runs with a given value of χ and with the values of *Ra* and *E* that are calibrated by scales of Ra_0*=4000,* 8000 and 10000, and $E_0 = O(10^{-4})$. We investigate features of lunar dynamo evolution in scenarios with different values of Ra_0. In summary, we find three types of dynamo regimes during the evolution of lunar core: self-sustaining regime, failing-dynamo regime with convection, and failing-dynamo regime without convection. From the results of the simulations, we find that dynamos cease under a low magnetic Reynolds number that causes the termination of convection because of slow inner core growth in a late phase. We also find that it is difficult to drive convection in the cases of thin shell (χ *=0.6* and 0.7) even with the highest Ra_0. This result might suggest a possible scenario in which the lunar dynamo driven by compositional convection shuts off.

Keywords: Lunar dynamo , Magnetic field of the Moon, Evolution of the Moon, Thermal history, Inner core growth, Compositional convection

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Investigation of sub-grid scale (SGS) model in dynamo simulations with small Ekman and magnetic Prandtl numbers

*Hiroaki Matsui[1]

1. Dept. of Earth and Planetary Sciences, University of California, Davis

The flow in the Earth's outer core is expected to have vast length scale from the geometry of the outer core to the thickness of the boundary layer. Because of the limitation of the spatial resolution in the numerical simulations, sub-grid scale (SGS) modeling is required to model the effects of the unresolved field on the large-scale fields. We model the effects of sub-grid scale flow and magnetic field using a dynamic scale similarity model. Four terms are introduced for the momentum flux, heat flux, Lorentz force and magnetic induction. The model was previously used in the convection-driven dynamo in a rotating plane layer and spherical shell using the Finite Element Methods.

In the present study, we perform large eddy simulations (LES) using the dynamic scale similarity model. The scale similarity model is implement in Calypso, which is a numerical dynamo model using spherical harmonics expansion. To obtain the SGS terms, the spatial filtering in the horizontal directions is done by taking the convolution of a Gaussian filter expressed in terms of a spherical harmonic expansion, following Jekeli (1981). A gaussian field is also applied in the radial direction.

In the present study, we evaluate SGS terms from direct simulation (DNS) without using SGS model. The resolved DNS is performed on the truncation degree $L = 1023$ using the Ekman number $E = 1.0 \times 10^{-6}$. To investigate optimal size of spatial filtering and limit of spatial resolution for the present SGS model, we evaluate the SGS terms with L = 255, 342, and 511, and compare with the SGS terms directly evaluated on the original fine resolution.

The results show that the amplitude of SGS inertia terms is larger than the SGS Lorentz force in the all length scale in the momentum equation, because the magnetic field has larger length scale than the velocity. The inertia term obtained by the resolved field decreases with the coarser resolution in all horizontal length scales. The amplitude of the SGS inertia term is approximately 0.28 times of the inertia term obtained by resolved fields.

Keywords: Geodynamo, Sub-grid scale model

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Growth rates of kinematic dynamos in a finite domain

*Ataru Sakuraba[1]

1. Department of Earth and Planetary Science, University of Tokyo

Kinematic dynamos have been intensively studied since 1950s to get an insight into generation mechanisms of planetary magnetic fields. Even today when computer simulations of geophysically realistic dynamo models are possible, importance of that classical problem cannot be neglected because of its use in understanding basic dynamo processes. For example, a linear growth rate of a kinematic dynamo model can be an important measure to estimate a timescale of geomagnetic field recovery from a weak-field state in a reversal transition, and to understand energy transfers from fluid flow to magnetic fields and dissipation. Most of previous studies on growth rates of kinematic dynamos have assumed fluid flows extending infinitely in space such as three-dimensionally periodic ABC flows (see a review by A. Soward, Fast dynamos, in Lectures on Solar and Planetary Physics, Cambridge Univ. Press, 1994). Here we consider a cylindrical annulus model of kinematic dynamo. The flow is periodic along the azimuthal direction but finite in the radial and axial directions. The magnetic field satisfies a pseudo-vacuum boundary condition for the sake of computational simplicity. The induction equation is integrated in time from a random field and a linear growth rate is estimated after calculation of several magnetic diffusion times. A background flow is chosen so that the flow component can be represented as a few terms of trigonometric functions in the cylindrical coordinates and the kinetic helicity is antisymmetric about the equator. The growth rate can be summarized as a function of the magnetic Reynolds number, R, and the azimuthal wavenumber, m, of the background flow. In a parameter domain of $R < 1000$, we observed an increase of the growth rate as mR to the power of 2/3.

Keywords: planetary magnetic field, dynamo, magnetohydrodynamics

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Detection of jerk-like magnetic field variation in a numerical dynamo model using wavelet analysis

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1. Faculty of Sciences, Kyushu University, 2. Department of Earth and Planetary Sciences, Kyushu University

Geomagnetic jerk is known as a sudden change in the trend of geomagnetic secular variation, which typically occurs in annual timescale. A conventional and direct way to identify jerks is by looking for V- or \Lambda-shaped changes in the slope of the secular variation of a field component at observatories. Instead, to find geomagnetic jerks, Alexandrescu et al. (1995) applied wavelet analysis to geomagnetic field data obtained at ground observatories in Europe. They detected geomagnetic jerks in 1901, 1913, 1925, 1969 and 1978, and showed that regularity of the magnetic field variation is about 1.5 rather than 2.

Although dynamo action in the Earth’ s core should generate such a singular variation, physical mechanisms responsible for jerks are still unknown. In this respect, numerical dynamo modeling could be useful, because all information within the core relating magnetic field variations can be obtained. However, magnetic field variation in dynamo models occurs more slowly compared with the geomagnetic secular variation probably due to assumed values of the fluid viscosity very far from that in the Earth’ s core. Therefore, it is not evident that any jerk-like fast magnetic field variation can be observed in numerical dynamo models. In this study, we report results of our attempt to detect jerk-like magnetic field variation in a numerical dynamo model using wavelet analysis. The Ekman number of the model is 3×10^{-5}, which is not the state-of-the-art but comparatively small, giving a good starting point.

Brief summary of the results is as follows: (1) Jerk-like magnetic field variation is detected in all of the three components; (2) Regularity of such variations is typically larger than 2; (3) Jerk-like variation occurs both globally and locally. Relevance of the present results to the geomagnetic jerk and relation to the internal dynamics are discussed based on these findings.

Keywords: Geomagnetic jerk, Dynamo, Wavelet analysis

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[J] Poster | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_15

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo)

We are going to discuss the issues on the magnetic fields of the Earth and planets, paleomagnetism, rock-magnetism, and their applications. This session includes following topics: (1) observation and analysis of the magnetic fields of the Earth and planets, (2) paleomagnetic field variations obtained from natural and archaeological materials, (3) numerical simulations on the magnetic fields of the Earth and planets, (4) measurements and theories of magnetic properties of rocks, minerals, meteorites, and other materials, (5) climate changes and surface tectonics based on the paleomagnetic measurements of rocks and sediments, (6) observations of the magnetic anomalies and the crustal magnetization models of the Earth, planets, and satellites, and (7) developments of the measurement method and data analysis. The presentation and discussion will be made in Japanese or English in this session.
This session contributes toward development of the SEDI-Japan community.

[SEM18-P01] Analyzing the early 19th cenytury's geomagnetic declination in Japan from Tadataka Inoh's Santou-Houi-Ki the 13th roeport.

*Motohiro Tsujimoto[1], Akitoshi Omotani[2] (1.Japan Cartographers Association, 2.San-in System Consultant)

[SEM18-P02] Forecasting geomagnetic secular variation based on magnetic diffusion at the core-mantle boundary

*Masaki Matsushima[1], Hisayoshi Shimizu[2], Futoshi Takahashi[3], Takuto Minami[2], Shin ya Nakano[4], Hiroaki Toh[5] (1.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 2.Earthquake Research Institute, University of Tokyo, 3.Faculty of Science, Kyushu University, 4.Institute of Statistical Mathematics, 5.Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University)

[SEM18-P03] Candidate models of IGRF13-SV from Japanese team

*Hisayoshi Shimizu[1], Takuto Minami[1], Shin ya Nakano[2], Futoshi Takahashi[3], Masaki Matsushima[4], Hiroaki TOH[5] (1.Earthquake Research Institute, University of Tokyo, 2.Institute of Statistical Mathematics, 3.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 4.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology , 5.Data Analysis Center for Geomagnetism and Space Magnetism, Kyoto University)

[SEM18-P04] **Preliminary report on the paleointensity variation during 38-50 Ma deduced from the marine sediments recovered from the northwest Atlantic**

*Yuhji Yamamoto[1], Hiroto Fukami[1,2], Wakana Taniguchi[1], Peter C. Lippert[3] (1.Center for Advanced Marine Core Research, Kochi University, 2.Sanyo Techno Marine Co., Ltd., 3.Department of Geology and Geophysics, University of Utah)

[SEM18-P05] The Gauss-Matuyama polarity transition record from the Plio-Pleistocene marine sequence of the Mera Formation, Chikura Group, in the southernmost part of the Boso Peninsula

*Makoto Okada[1], Yosuke Hiraoka[2], Daisuke Hasegawa[2] (1.Department of Earth Sciences, Faculty of Science, Ibaraki University, 2.Graduate School of Science and Engineering, Ibaraki University)

[SEM18-P06] Holocene paleomagentic secular variation recorded in sediments from Lake Tazawa in Akita Prefecure, Northeast Japan

*Ryo Yasuda[1], Akira Hayashida[1], Kazuyoshi Yamada[2], Hiromi Matsuoka[3], Makoto Okamura[3], Daizo Ishiyama[4] (1.Doshisha University, 2.Museum of Natural and Environmental history, Shizuoka, 3.Kochi University, 4.Akita University)

[SEM18-P07] Geomagnetic excursions observed in Lake Suigetsu varved sediments during the latest stage of the last glacial period

*Shota Tanabe[1], Masako Miki[1], Masayuki Hyodo[2], Takeshi Nakagawa[3], Ikuko Kitaba[3], Keitaro Yamada[3], Junko Kitagawa[4], Suigetsu 2014 Project Members[5] (1.Kobe University, 2.Research Center for Inland Seas, Kobe University, 3.Ritsumeikan University, 4.Fukui Prefectural Satoyama-Satoumi Research Institute, 5.www.suigetsu.org)

[SEM18-P08] Geo-electromagnetic research at a spreading center of a divergent plate boundary in Afar depression, Ethiopia

*Naoto Ishikawa[1], Ryokei Yoshimura[2], Tesfaye Kidane[11], Shin-ichiro Higashino[3], Shin-ichi Kagashima[4], Nobutatsu Mochizuki[6], Ameha A. Muluneh[5], Kirika Kitagawa[4], Mamoru Kadoya[7], Noriaki Obara[10], Yo-ichiro Otofuji[9], Minoru Funaki, Tetsu Kogiso[1], Masakazu Fujii[8] (1.Graduate School of Human and Environmental Studies, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University, 3.Graduate School of Engineering, Kyushu University, 4.Yamagata University, 5.Addis Ababa University, 6.Kumamoto University, 7.X-TREME COMPOSITE JAPAN, 8.National Institute of Polar Research, 9.Japan Geochronology Network, 10.Robotista, 11.University of KwaZulu Natal)

[SEM18-P09] Verification of reducitive chemical demagnetization effect on the sedimentary rocks from the Kokumoto Formation, Kazusa Group, Boso Peninsula

*Takahiro Kitamura[1], Makoto Okada[1], Yuki Haneda[1], Chisato Anai[2], Hidetoshi Shibuya[2] (1.Ibaraki University, 2.Dep't Earth & Env. Sci., Kumamoto Univ.)

[SEM18-P10] Hole surface survey monitoring test using by rock magnetic analysis

*Noriko Kawamura[1], Naoto Ishikawa[2] (1.Japan Coast Guard Academy, 2.Graduate School of Human and Environmental Studies, Kyoto University)

[SEM18-P11] Rock magnetic measurements of Miocene dikes at the western margin of the Shitara Igneous Complex, central Japan

*Kohei Yamamoto[1], Hiroyuki Hoshi[2] (1.Graduate School of Education, Aichi University of Education, 2.Aichi University of Education)

[SEM18-P12] Eliminating spurious magnetic phases of sedimentary rocks using reductive chemical treatments – A thermomagnetic experiment study on the Upper Cretaceous Yezo Group-

*Chisato Anai[1], Hidetoshi Shibuya[1], Nobutatsu Mochizuki[1] (1.Kumamoto University)

[SEM18-P13] Rock-magnetic studies on seafloor hydrothermal deposits in the Okinawa Trough

*Chie Kato[1], Masao Ohno[1], Tadahiro Hatakeyama[2], Jun-ichiro Ishibashi[3], Shuhei Totsuka[4], Kazuhiko Shimada[3] (1.Department of Environmental Changes, Faculty of Social and Cultural Studies, Kyushu University, 2. Information Processing Center, Okayama University of Science, 3.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 4. Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University)

[SEM18-P14] Rock-magnetic study of fresh dunite in the Horoman peridotite complex, Hokkaido, Japan

*Nobutatsu Mochizuki[1], Satoko Ishimaru[1], Shoji Arai[2] (1.Department of Earth and Environmental Science, Faculty of Advanced Science and Technology, Kumamoto University, 2.Department of Earth Sciences, Faculty of Science, Kanazawa University)

[SEM18-P15] Improvements of sensitivity and utility in the scanning superconducting quantum interference device (SQUID) microscope

*Yusuke Kubota[1], Joseph Kirschvink[2,1], Isaac Hilburn[2], Jennifer Buz[3], Atsuko Kobayashi[1,2], Chie Kato[4]
(1.Tokyo Institute of Technology, 2.California Institute of Technology, 3.Northern Arizona University, 4.Kyushu University)

Analyzing the early 19th cenytury's geomagnetic declination in Japan from Tadataka Inoh's Santou-Houi-Ki the 13th roeport.

*Motohiro Tsujimoto[1], Akitoshi Omotani[2]

1. Japan Cartographers Association, 2. San-in System Consultant

The Santou-Houi-Ki is a national treasure of Japan 67 volumes magnetic survey ledger recorded by cartographer Tadataka Inoh in 1800 to 1816,consist of approximately 200,000 magnetic compass land survey azimuth data accuracy of 0 degree 5 min, from the coast of eastern Hokkaido to Yakushima Island in Western Japan. I restarted the analysis stopped after only one analysis in 1917,which done about the magnetic compass survey azimuth data at known position of the retirement home of Tadataka Inoh at Fukagawa in Edo (Tokyo) in 1802-1803,by interdisciplinary simultaneous analysis across geomagnetism, survey science, historical cartography and local history.
(1)Interdisciplinary simultaneous analysis: We can increase precise evidence to verify the real azimuth, geomagnetic declination and the reference point where magnetic compass survey was executed, or survey target points recorded in the Santou-Houi-Ki, than traditional way of study separated in each field.
(2) Procedure of analysis: Use the recreation software of scenery and digital map of GSI Japan Chiriin Chizu to know the latitude and longitude accuracy sec of particular survey target points, and the outline position of survey reference point to grasp the outline of each real azimuth from the survey reference point to survey target points. Geomagnetic declination=Real azimuth-Magnetic compass survey azimuth recorded in the Santou-Houi-Ki. Calculate backward the precise position of the survey reference point should be adjusted to the position in accuracy 0.001sec.in latitude and longitude, where all of geomagnetic declination unit of 0.01sec. Calculate from the magnetic compass survey azimuth to each different targets at the reference point are approximately equal to each other. Calculate the average value of each declination unit of 0.001sec.and express it as the geomagnetic declination unit of 1min.on the day and point Tadataka Inoh's magnetic compass survey was executed. To use the consecutive formula of Excell for speed up and Keep accuracy. If it possible to go to the field of the survey reference point, confirm the real scenery and the longitude and latitude by GPS transmitter and recalculate the value of geomagnetic declination.
(3) The outline of isogonic line in Japan archipelago and the distribution of the declination in every 15 min in western Japan coast in those days. begin to appear. Compare the isogonic line of declination in those year's Japanese archipelago by analysis of The Santou-Houi-Ki,with the Historical Magnetic Declination map by NOAA(1800,1805,1810,1815)is the NOAA's pace of variation West is almost 5 years later than the analysis of the Santou-Houi-Ki in western Japan. (4)However, from the analysis of Santou-Houi-Ki, we can recognise the magnetic declination supposed as the local geomagnetic declination anomaly in southern coast of eastern Hokkaido, some part of Noto Peninsula, Mt. Asama in Ise, Nobeoka city in Kyushu Island etc. and revealed the long western coast of Tsushima island etc.,impossible to drew in Historical Declination Viewer by NOAA. The analysis is developed from the coast area of Japanese archipelago to the inland area of Honshu island. (5)It is able to restore the precise position of survey reference points where Tadataka Inoh's magnetic compass survey was executed the accuracy of less than sec in latitude and longitude ,valuable in local history. It is so accurate as impossible to achieve by other way of study.(6)It is able to change Japan as the concentrated area of data in early 19th century from insufficient area of data and supply data to north east Asia.
Total number of analyzed points exceeded 229. (7)We started the discussion to compile those analysis to the database available to Archeomagnetiism Data base, or NOAA’ s Historical Declination Viewer.In this year I will focus on between Niigata prefecture including Sadogashima island from Ishikawa prefecture.

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Keywords: geomagnetic declination , Tadataka Inoh, Santou-Houi-Ki, reference point , target point, interdiciplinary

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Forecasting geomagnetic secular variation based on magnetic diffusion at the core-mantle boundary

*Masaki Matsushima[1], Hisayoshi Shimizu[2], Futoshi Takahashi[3], Takuto Minami[2], Shin ya Nakano[4], Hiroaki Toh[5]

1. Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 2. Earthquake Research Institute, University of Tokyo, 3. Faculty of Science, Kyushu University, 4. Institute of Statistical Mathematics, 5. Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University

The International Geomagnetic Reference Field (IGRF) is a standard mathematical description in terms of spherical harmonic coefficients, known as the Gauss coefficients, for the Earth's main magnetic field and its secular variation, updated every five years. In the next IGRF revision, the 13th generation of IGRF (IGRF-13), the Definitive Geomagnetic Reference Field for 2015 (DGRF-2015), the IGRF for 2020 (IGRF-2020), and the Secular Variation (SV) from 2020 to 2025 (SV-2020-2025) are to be released. We are planning to submit a model of SV-2020-2025 using our strong points, such as geodynamo numerical simulations, data assimilation, and core surface flow modeling.

Forecasts of geomagnetic SV are likely to require geomagnetic secular acceleration (SA), which can be expressed in terms of core fluid velocity and acceleration in the first time derivative of induction equation. In fact, Whaler and Beggan (2015) pointed out that forecasts of the Earth's main magnetic field and its temporal changes are improved for a model in which fluid velocity and acceleration are included. They also suggested that the quality of forecasts might be lowered for a period during which a geomagnetic jerk, a sudden temporal change in the geomagnetic acceleration, occurs. On the other hand, however, Fournier et al. (2015) pointed out that core flow acceleration could be neglected to forecast SV through data assimilation. Thus it is important to clarify the necessity of employing core flow acceleration.

In this presentation, we investigate whether or not geomagnetic SA is of importance to forecast geomagnetic SV, taking into account geomagnetic jerks occurred in 2003 and 2007 (e.g. Olsen and Mandea 2007; Chulliat et al. 2010). We assume that geomagnetic SV is caused only by magnetic diffusion at the core-mantle boundary, because core flow should vanish at the core surface on the no-slip boundary condition. We also show that the present method of forecasting the Earth's main magnetic field and its SV is consistent with simple analytical extrapolation of geomagnetic field. In other words, such simple extrapolation is based on a physical phenomenon of magnetic diffusion.

Keywords: IGRF, geomagnetic secular variation, magnetic diffusion

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Candidate models of IGRF13-SV from Japanese team

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International Geomagnetic Reference Field (IGRF) and its secular variation models are open to public every five years. Next IGRF models, the Gauss coefficients to represent the spatial distribution of the field at epoch 2020.0 and its secular variation (first time derivatives) in the period from 2020.0 to 2025.0, will be determined and published around December, 2019, by Working Group of IAGA V-MOD. The IGRF and its secular variation models are determined based on candidate models submitted by research groups for Working Group V-MOD. We plan to submit a candidate secular variation model to contribute for determining IGRF13-SV.
Prediction of the main geomagnetic field is necessary to obtain a candidate model for IGRF and its secular variation. Although purely statistical prediction, which had been a usual procedure in the past, can be a possible method, we employ physics-based modeling for the prediction. Since the parameters used for geodynamo calculations are not "realistic" values for the Earth's core, it is not appropriate to take geodynamo solutions as they are for the predictions. Nevertheless, it is possible to select parameter set and appropriate normalizing time-scales to obtain modeled magnetic field that is similar to the geomagnetic field. In this presentation, we are going to show candidate models of secular variation obtained by geodynamo data assimilation with discussions on the time-scales, the method of assimilation, and data-set employed for the modeling.

Keywords: IGRF, geodynamo modeling, geodynamo data assimilation

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Preliminary report on the paleointensity variation during 38-50 Ma deduced from the marine sediments recovered from the northwest Atlantic

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Variations of the intensity of the paleomagnetic field (paleointensity), which provide clues about the evolution of the geodynamo, are recorded in rocks and sediments. Marine sediments give relative paleointensity (RPI) continuously in time. For the period of 0-2 Ma global RPI stacks [1][2] have been reported based on numerous regional RPI records. For the period of 2-3 Ma there have been increasing number of regional RPI records [3][4]. However, published RPI records older than ~3 Ma are very limited in time and space: 14.5-18.5 Ma [5], 17.5-26.5 Ma [6], 23-41 Ma [7] from the equatorial Pacific; 23-34 Ma from the South Atlantic [8]. We have conducted a paleomagnetic study on the marine sediments recovered in the northwest Atlantic to extend our knowledge of the RPI variation in further geologic past, and report on the preliminary RPI results for the period of about 38-50 Ma.

Integrated Ocean Drilling Program (IODP) Expedition 342 recovered hemipelagic sediment drifts from Sites U1403 and U1408 in the northwest Atlantic, off the coast of Newfoundland [9]. Piston cores of the two sites were subjected to a series of the paleomagnetic measurements including analyses of natural, anhysteretic, and isothermal remanent magnetizations (NRM, ARM, and IRM). Excluding the intervals showing signs of probable dissolution of primary magnetic minerals (low ARM intensity intervals) and inhomogeneous magnetic grain sizes (mainly for low ARM/IRM intervals), RPIs were estimated based on ratios of NRM/ARM and NRM/IRM.

Considering age models of the studied cores [10][11], the resultant RPI records cover the Chrons 18 (38.5-41.1 Ma), 19 (41.1-42.9 Ma), 20 (42.9-46.4 Ma), 21r (47.8-48.6 Ma), and 22n (48.6-49.3 Ma). These records are characterized by RPI minima always at chron boundaries and large fluctuations between highs and lows during each chron. Such charactersistics are commonly recognized in the published RPI records back to 41 Ma [1-8]; this is first record to show that they persist at least since 49.3 Ma.

For the Chron 18 interval, we obtained RPI results from both sites, which are approximately 380 km apart (Figure 1). Our results show common features, including RPIs that are generally high during C18n.2n (39.6-40.0 Ma) and low during C18r (40.0-41.1 Ma). Prominent RPI lows, which appear to be almost equivalent to the RPI minima at other chron boundaries (*i.e.*, during Chrons 19, 20, 21r, and 22n), are also commonly recognized at ~40.5 Ma. We suggest that the RPI lows might be related to a failed geomagnetic reversal.

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The Gauss-Matuyama polarity transition record from the Plio-Pleistocene marine sequence of the Mera Formation, Chikura Group, in the southernmost part of the Boso Peninsula

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We aim to reconstruct a detailed geomagnetic field variation during the Gauss-Matuyama polarity transition which has a fewer study cases compare to the Matuyama-Brunhes boundary, we have conducted a paleomagnetic study on the Plio-Pleistocene marine sequence of the Mera Formation, Chikura Group.

In the section of the layer thickness of 36.4 m in the middle part of the cloth layer containing the G-M boundary, samples for palaeomagnetic measurements were placed at intervals of about 5 to 30 cm in the layer intervals of 12.1 to 19.1 m, at intervals of about 1 m in the layer intervals of 25.4 to 36.4 m , From a total of 72 layers. As a result of rock magnetometry measurements, the change in the magnetic minerals which is obvious lower and upper than the layer thickness of 19.1 m was caught. In addition, the transition of the magnetization direction from the positive magnetic pole to the reverse magnetic pole was captured in the layer intervals of 12.5 to 13.3 m from the restored VGP fluctuation. Since the relative paleomagnetic intensity at that time attenuates to about 1/4 of the normal time, we considered that the G-M boundary was recorded in this level. The restored VGP fluctuation can be confirmed to be stagnant in the mid latitudes after reversal. This is consistent with the record of the Gauss-Matsuyama boundary restored by Ohno et al. (2012).

Keywords: Gauss-Matuyama boundary, Chikura Group

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Holocene paleomagentic secular variation recorded in sediments from Lake Tazawa in Akita Prefecure, Northeast Japan

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We conducted a paleomagnetic study of three piston-core samples from Lake Tazawa in Akita Prefecture, aiming at reconstruction of the paleomagnetic secular variation in Northeast Japan. An age-depth model based on radiocarbon dating shows that the core samples cover the last 7500 cal year BP in the Holocene. Measurements of natural remanent magnetization (NRM) and anhysterresis remanent magnetization (ARM) were carried out on U-channel samples by a pass-through method with a 2G-Enterprises superconducting rock magnetometer. Then, we made deconvolution of the pass-through data by using the software UDECON (Xuan and Oda, 2015), which searches the optimum result in the ABIC-minimizing single smoothness-parameter scheme assuming smoothness in variation of the sediment magnetization. Low-field magnetic susceptibility of the U-channel samples was also measured by a pass-through method and deconvolved using the software, which we developed in two schemes, first assuming a single smoothness parameter for the entire sample (mono-decon) and then introducing an additional parameter for a specific interval (dual-decon). The program “dual-decon” enables us to assign the second hyper-parameter for the interval with a sharp susceptibility peak such as a tephra layer and an event layer. Experiments using a simulated continuous sample made by connecting discrete cubic samples (“cube-train”), which contains the B-Tm tephra layer, showed that the dual-decon produces the better result which is consistent with the discrete measurements rather than the mono-decon. It is suggested that the noise originated from a sharp increase could be reduced by introducing the second smoothness-parameter in the deconvolution process. Principal component analysis of the alternating-field demagnetization data after the deconvolution by UDECON revealed existence of characteristic magnetic components, which can be regarded representing the past geomagnetic field. In particular, the declination after 3,000 cal yr BP shows consistent variations between the cores. This variation also shows a good similarity with a global archaeomagnetic secular variation model, ARCH3k.1, and the paleomagnetic record from Lake Biwa (BIWA SV-3), implying importance for reconstruction of the paleosecular variation in Northeast Japan. On the other hand, estimation of relative paleointensity was difficult, mainly due to ununiformity of concentration and grain-size of magnetic minerals, suggested by variation of the ARM, the low-field susceptibility and the ARM susceptibility/susceptibility ratio.

Keywords: paleomagnetic secular variation, Holocene, deconvolution

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Geomagnetic excursions observed in Lake Suigetsu varved sediments during the latest stage of the last glacial period

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A geomagnetic excursion is a brief event that the geomagnetic field direction deviates largely from a normal one, generally lasting for less than two thousand years. The relative paleointensity data stack Sint-800 revealed that the excursions during the Brunhes Chron occurred when the dipole magnetic field strength decreased below 50% of the present one. However, some previous studies report some geomagnetic excursions may be unrelated to weakening of the geomagnetic field. We conducted paleomagnetic analyses of the Lake Suigetsu varved sediments in order to detect unknown excursions during the past ca. 20 ka.

We analyzed the Fukui-SG14 core collected in 2014 from Lake Suigetsu. Paleomagnetic analyses were conducted on LL-channel sections of 1 m length with a cross section of 2 cm ×2 cm, with stepwise alternating field demagnetizations at depth intervals of 1 cm (about 14 years in time) over a composite-depth range from 900 cm - 2100 cm (correlation model version 08 May 2016). Principal component analysis was performed on the demagnetization data at 852 depth levels, and positions of virtual geomagnetic poles (VGPs) were calculated. As a result, we found three geomagnetic excursions including successive directions with VGPs lower than 45˚N, between 1700 cm and 2000 cm in depth. The three excursions are tentatively named A, B, and C in the descending order. The detailed chronology of the Fukui-SG14 based on the high-resolution correlation with the SG06 age model provides their mid-ages (durations) are about 15.3 $SG06_{2012}$ kyr BP (about 370 yr), 17.7 $SG06_{2012}$ kyr BP (about 130 yr), and 19.4 $SG06_{2012}$ kyr BP (about 380 yr), respectively. The intensities in the geomagnetic excursions we observed do not decrease.

We also conducted stepwise thermal demagnetizations with some samples from the excursion zones. The results confirmed presence of the excursions.

The thermomagnetic analyses and isothermal remanent magnetization (IRM) acquisition experiments show that the main magnetic carriers are magnetite and greigite.

Keywords: geomagnetic excursion

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Geo-electromagnetic research at a spreading center of a divergent plate boundary in Afar depression, Ethiopia

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In order to clarify the formation process of magnetic stripes and structure under a sea-floor spreading center at the divergent plate boundary, we are performing an on-land geo-electromagnetic research project in Afar Depression, Ethiopia, where we can investigate into a subaerial sea-floor spreading center directly. We will introduce the outline of our project and report preliminary results form 2016-2018 field surveys and data analyses.

Keywords: divergent plate boundary, sea-floor spreading, maginetic anomaly, geo-electromagnetic research, small unmanned aircraft

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Verification of reducitive chemical demagnetization effect on the sedimentary rocks from the Kokumoto Formation, Kazusa Group, Boso Peninsula

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The Matuyama-Brunhes boundary (M-B boundary) has been confirmed in the Chiba composite section which is the lower-middle Pleistocene boundary GSSP candidate site composed of the Kokumoto formation, Kazusa Group, and paleomagnetic studies have been actively conducted. During a geomagnetic polarity transition, since the geomagnetic intensity remarkably decreases, the primary magnetization is generally recorded very weakly in sedimentary rocks. In the Kokumoto formation, it is cosidered that chemical remanent magnetization due to the magnetic mineral made secondarily is responsible for the secondary magnetization, and it is impossible to separate the primary and the secondary magnetizations by alternating field demagnetization (AFD). On the other hand, in the thermal demagnetization (TD), the secondary magnetization is successfully demagnetized by heating at 400 ℃ or more, but due to the thermal decomposition of magnetic minerals, additional magnetic minerals are newly generated during demagnetization, so that the relative paleointensity can’ t be restored. Okada et al. (2017) restored magnetostratigraphy by combination demagnetization (TD in 300 ℃ + progressive AFD) to avoid thermal decomposition of magnetic minerals. However, minerals that cause secondary magnetization remain in the specimen, and there is a possibility that it may hinder the restoration of the primary magnetization as noise. Therefore, in this research we attempted chemical removal of minerals responsible for secondary magnetization by reductive chemical demagnetization (RCD), a method established by Anai et al. (2017).
In this study, RCD was performed on 4 samples collected between the Byk-E and Byk-A key tephra beds, in which the directional polarity reversal corresponding to the M-B boundary was confirmed in Okada et al. (2017). For RCD, an etchant solution whose pH was adjusted with sodium bicarbonate in a 5 % ascorbic acid aqueous solution was used. Thermomagnetic measurements in air were carried out on samples for both of subjected and not subjected to RCD and the sample not subjected to RCD. RCD s were performed by dropping a solution onto two samples out of four samples and immersing the remaining two samples in a solution. Then, thermomagnetic measurements were carried out again on samples for both of subjected and not subjected to RCD. In all the samples not subjected to RCD, the saturation magnetizations which showed gradual decreasing with increasing temperature rose greatly at around 400 ℃. On the other hand, in samples subjected to RCD, it was observed that the increase in saturation magnetization at around 400 ℃ was suppressed. These results suggest that minerals related to thermal alteration is eluted by RCD, and dripping is better than dipping as a method of RCD.

Keywords: Reductive chemical demagnetization, chemical remanent magnetization, Matuyama-Brunhes boundary, Chiba composite section

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Hole surface survey monitoring test using by rock magnetic analysis

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For a successful criminal conviction to occur, it is essential to locate forensically important evidences which are disposed in soil. In this study, we attempted rock magnetic method as a forensic search tool to detect evidences in soil. A 2.5 m long survey line was provided in the campus ground of Japan coast guard academy, 0.1 m×0.2 m×0.7 m sized hole was created and was buried into the sand soil. Magnetic susceptibility (MS) was measured using by a ZH instruments magnetometer every 0.1 m along the line, and was measured six times at every position. MS indicates relative higher values at the disturbed ground. A core sample in 7 cm length was collected using by a soil sampler at around the disturbed ground. The soil core was consisted of silty sand with granule, and the grain size of soil increases with burial depth. Dried soil samples were packed into 1 cm^3 plastic cubes every 1 cm from the core. Rock magnetic measurements, MS, anhysteretic remanent magnetization (ARM), isothermal remanent magnetization (IRM) were conducted for the cube samples. The powder soil samples of isothermal magnetization (M_{rs}), saturation magnetization (M_s), coercivity (H_c), and remanence corecivity (H_{cr}) were measured. MS shows a peak at 2 cm in depth. Values of ARM and IRM gradually decrease with depth. It is implied that the relative high MS of disturbed ground was caused by the mixed lower soil. In order to identify magnetic minerals in the soil samples, thermomagnetic analysis (Js-T) was performed on four samples which are collected from the soil core of surface (0-0.2 m), middle (0.3-0.5 m) and deep parts (0.6-0.7 m) and the surface soil at the disturbed ground. All samples indicate declines of Js-T curves at 580°C and 680°C. A slight inflection in Js-T curves at around 300°C -400°C is also recognized, the presence of maghemite and hematite is thus suggested. M_{rs}/M_s and H_{cr}/H_c values of the core samples are plotted in the pseudo-single domain (PSD) region for (titano-) magnetite on the Day plot, and indicate that grain size of magnetic minerals downward decrease. The values of disturbed ground are located the central part of all samples which are implied that the mixed lower soils were contributed. The MS peak have been recognized after eight months although the disturbed ground covered by weeds and the hole is invisible. This result proves that MS can detect the location of disturbed ground over eight months post-disturbance. It is suggested that MS is effective for detecting the location of disturbed ground.

Keywords: forensic science, rock magnetism, environmental magnetism

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Rock magnetic measurements of Miocene dikes at the western margin of the Shitara Igneous Complex, central Japan

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We performed rock magnetic measurements for Miocene andesite dikes intruding granitic and metamorphic rocks of the Ryoke belt of the Mikawa district, Aichi Prefecture, in order to reveal the rock magnetic characteristics of the dikes. We collected andesite samples both from dark gray, apparently fresh rocks and gray to white, slightly to severely altered rocks. Thermomagnetic (magnetic susceptibility vs temperature) analysis and thermal demagnetization of composite isothermal remanent magnetization (IRM) yielded data showing that both titanomagnetite and pyrrhotite are contained in the majority of the samples. At one site, we found that pyrrhotite is the only magnetic mineral carrying the remanent magnetization. The pyrrhotite that we identified at almost all sampling sites is thought to have been precipitated as a secondary mineral by hydrothermal alteration, or formed as a primary mineral in a reductive condition during solidification of magmas in the host meta-sedimentary rock.

Keywords: Shitara Igneous Complex, dikes, paleomagnetism, rock magnetism, magnetic minerals

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Eliminating spurious magnetic phases of sedimentary rocks using reductive chemical treatments –A thermomagnetic experiment study on the Upper Cretaceous Yezo Group-

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Sedimentary rocks often have secondary components of chemical remanent magnetizations (CRM) during post-depositional processes, lithification, diagenesis, and/or later chemical events, in addition to the primary detrital remanent magnetization (DRM). These secondary components are carried by secondarily formed minerals of iron-oxides, hydroxides, and/or sulfides. These secondary minerals are produced by Fe-ions contained in pore water and/or sedimentary rocks itself. Therefore, secondary CRM carriers precipitate in the space between mineral particles and/or the voids of the sedimentary rocks, since these parts are reached first by pore water from outside of the samples. The secondary minerals often have a large thermal alteration during thermal demagnetization experiments. Thermal alterations at high temperature steps often introduce large laboratory-CRM, which masks the primary component. Those CRM acquired in the furnace could be reduced by removing secondary magnetic minerals using reductive chemical demagnetization (RCD) beforehand (Anai et al., 2018). In this study, we show the results of rock magnetic and paleomagnetic experiments of samples from the Upper Cretaceous Yezo Group, in order to see whether the RCD is effective reducing such spurious magnetic components.
A pair of chip samples were prepared from paleomagnetic cores. One of the chip samples was subjected to RCD, and the other remained intact. The RCD is performed by dipping the chip sample in the etchant for 72 hours (recipe: Ascorbic acid 5%, buffered by sodium bicarbonate, and adjusted to pH= ~5.6, ORP= -150 to -50 mv). Strong-field thermomagnetic analyses were conducted on both chip samples with and without the RCD. Thermomagnetic curve of the samples without RCD show 4 types of thermal alternation behavior. As a characteristic example of the result Type-C is as follows: magnetization (Js) increases around 400˚C. The increase of Js makes a peak at 450˚C and then Js gradually decreases to zero at 580˚C. Abrupt increases of Js around 450˚C was not observed for the RCD sample, while the Js drops at 150˚C and 580˚C are the same as those observed for the samples without RCD. These results suggest that the iron-containing minerals, which changed to minerals carrying CRM around 450˚C, had been effectively removed by RCD. The results suggested that the RCD pretreatment may suppress thermal alteration of sedimentary rocks. This approach seems to have potential for reducing spurious secondary magnetic components effectively, though the relation between the thermal alteration and spurious magnetic components is not well understood.

Keywords: Yezo Group, Reductive chemical demagnetization

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Rock-magnetic studies on seafloor hydrothermal deposits in the Okinawa Trough

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Investigation of the mineral assemblage of seafloor hydrothermal deposits are crucial for understanding its formation environment and process. Rock-magnetic measurements of the deposits are quick and effective to detect magnetic metal sulfides which are sensitive to the environment. We report our results of rock-magnetic measurements conducted on sulfide ores from seafloor hydrothermal deposits in the Okinawa Trough. One sample is a sulfide ore of chimney structure collected from hydrothermal mound in the Noho Site and others are sediment core samples drilled at the Izena Hole.
X-ray diffraction (XRD) measurements and chemical analyses indicate that the chimney structured ore mainly consist of pyrrhotite and a Cu-Fe-S sulfide. Crystal structure of the Cu-Fe-S sulfide is similar to that of sphalerite and its chemical composition is close to $CuFe_2S_3$. From these characters, $CuFe_2S_3$ isocubanite is the candidate for the Cu-Fe-S sulfide.
Since the magnetic properties of $CuFe_2S_3$ isocubanite were rarely found in the literature, we first conducted low-temperature magnetometry measurements and magnetic hysteresis measurements of isocubanite. Isocubanite was synthesized by heating a cubanite sample (from Henderson No.2 mine, Chibougaman, Qubec, Canada) at 300 ℃ in vacuum (e.g. Sawada et al., 1962; Nenasheva and Kravchenko, 2015). Results of the magnetic measurements showed that isocubanite is weakly ferromagnetic at room temperature, and undergo a magnetic transition to relatively strong ferromagnetic at ~100 K. Saturation magnetization was 0.09 Am^2/kg at room temperature and 0.4 Am^2/kg at 50 K. Similar magnetic measurements were performed on the Cu-Fe-S sulfide in the chimney ore which was magnetically separated from pyrrhotite. The Cu-Fe-S sulfide was paramagnetic at room temperature and became ferromagnetic at below ~100 K. Saturation magnetization at 50 K was ~20 Am^2/kg. Such strong magnetization and sharp magnetic transition at low temperature is inconsistent with the behavior of isocubanite, but rather comparable to that of $Cu_{1-\varepsilon}Fe_{3+\varepsilon}S_4$ 'new phase' reported by Wintenberger et al. (1994) as an ageing product of isocubanite. Results of our magnetic measurements indicate that 'new phase' is a solid solution which includes $CuFe_2S_3$ composition.
Some of the sediment core samples contain a Cu-Fe-S sulfide with similar XRD pattern and chemical composition to that found in the chimney ore. Those sediment core samples also show a magnetic transition at ~100 K. Intensity of the magnetization at low temperature could be explained by assuming that the Cu-Fe-S sulfide in the sediment core samples is isocubanite, based on rough estimate of mineral proportion from XRD.

Keywords: Hydrothermal deposits, Cu-Fe-S sulfide, Low-temperature magnetometry

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Rock-magnetic study of fresh dunite in the Horoman peridotite complex, Hokkaido, Japan

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Magnetic anomalies observed on Earth are originated from remanent/induced magnetizations of the crust and probably those of the uppermost lithospheric mantle. For the lithospheric mantle, rock-magnetic data were mostly reported from serpentinized peridotites although some data were available for fresh mantle xenoliths from a few volcanoes. Since fresh peridotite samples are relatively scarce, the original magnetic properties of peridotite are not well studied. Rock-magnetic studies on fresh peridotites are required to characterize magnetization of the lithospheric mantle. In the present study, we report rock magnetic properties of fresh dunite samples and discuss the possibility of a source of magnetic anomaly on Earth and the other planets. The samples used in this study are collected from spinel-rich dunite-wehrlite (SDW) suite, mainly composed of clinopyroxene-bearing dunite, in the Horoman peridotite complex, Hokkaido, Japan (Takahashi, 1991). Fresh dunite samples were collected from a 20 m wide outcrop of SDW suite. Minute magnetite inclusions, which show elongated rod-like shapes, were observed in olivine grains under the microscope. It should be noted that the elongated magnetite inclusions are not associated with serpentinization. Densities of the samples mostly ranged in 3250-3350 kg/m^3, which correspond to typical values of fresh peridotite. A diagram of natural remanent magnetization (NRM) versus susceptibility shows that the data of the samples are clearly different from the data reported from serpentinized peridotites. Several samples have NRM values of 1-20 A/m, which are comparable to NRM values of volcanic rocks. A dunite layer of such strong NRM could be a potential source of magnetic anomalies.

Keywords: magnetization, dunite, Horoman peridotite complex

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Improvements of sensitivity and utility in the scanning superconducting quantum interference device (SQUID) microscope

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Superconducting quantum interference device (SQUID) microscopes have been used for mapping the distribution of ferromagnetic materials in a variety of industrial, biological, and geological materials. The advantage of the SQUID microscope is the wide dynamic range and spatial resolution down to the 25 μm scale, as well as the ability to quantify the direction and intensity of extraordinarily tiny magnetic dipoles. However, a major drawback of earlier versions of this instrument has been the need to cool the superconducting sensors with liquid helium and nitrogen, which limits the system's utility and drives up maintenance costs. One previous instrument (at Caltech) incorporated a closed-cycle pulse-tube cryocooler and managed to achieve good sensitivity by averaging precisely over one pulse cycle to remove the periodic magnetic signal from the pulse tube ferrite chain. In this study, we report a new design of SQUID microscope at TokyoTech that improves substantially on this. First, a large-volume μ-metal shielded room provides an environment with low spatial magnetic gradients, although it does allow ~ 5 nT low-frequency signals from local train lines to penetrate. Next, the pulse-tube is encased in a superconducting shield made of Pb, lowering the noise from that source. Finally, we placed a second SQUID sensor, parallel to the axis, ~4 cm from the first and calibrated it to correct for background fluctuations. The final system is approximately 5-10 times more sensitive than the previous configuration and is being applied to a variety of biological and single-crystal rock magnetic studies.

Keywords: SQUID microscope, Rock magnetism

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[J] Poster | S (Solid Earth Sciences)：S-EM Earth's Electromagnetism

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_27

[S-EM18] Geomagnetism, paleomagnetism and rock magnetism

convener:Hisayoshi Shimizu(Earthquake Research Institute, University of Tokyo), Masahiko Sato(Department of Earth and Planetary Science, The University of Tokyo)

We are going to discuss the issues on the magnetic fields of the Earth and planets, paleomagnetism, rock-magnetism, and their applications. This session includes following topics: (1) observation and analysis of the magnetic fields of the Earth and planets, (2) paleomagnetic field variations obtained from natural and archaeological materials, (3) numerical simulations on the magnetic fields of the Earth and planets, (4) measurements and theories of magnetic properties of rocks, minerals, meteorites, and other materials, (5) climate changes and surface tectonics based on the paleomagnetic measurements of rocks and sediments, (6) observations of the magnetic anomalies and the crustal magnetization models of the Earth, planets, and satellites, and (7) developments of the measurement method and data analysis. The presentation and discussion will be made in Japanese or English in this session.
This session contributes toward development of the SEDI-Japan community.

[SEM18-P01] Analyzing the early 19th cenytury's geomagnetic declination in Japan from Tadataka Inoh's Santou-Houi-Ki the 13th roeport.

*Motohiro Tsujimoto[1], Akitoshi Omotani[2] (1.Japan Cartographers Association, 2.San-in System Consultant)

[SEM18-P02] Forecasting geomagnetic secular variation based on magnetic diffusion at the core-mantle boundary

*Masaki Matsushima[1], Hisayoshi Shimizu[2], Futoshi Takahashi[3], Takuto Minami[2], Shin ya Nakano[4], Hiroaki Toh[5] (1.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 2.Earthquake Research Institute, University of Tokyo, 3.Faculty of Science, Kyushu University, 4.Institute of Statistical Mathematics, 5.Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University)

[SEM18-P03] Candidate models of IGRF13-SV from Japanese team

*Hisayoshi Shimizu[1], Takuto Minami[1], Shin ya Nakano[2], Futoshi Takahashi[3], Masaki Matsushima[4], Hiroaki TOH[5] (1.Earthquake Research Institute, University of Tokyo, 2.Institute of Statistical Mathematics, 3.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 4.Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology , 5.Data Analysis Center for Geomagnetism and Space Magnetism, Kyoto University)

[SEM18-P04] **Preliminary report on the paleointensity variation during 38-50 Ma deduced from the marine sediments recovered from the northwest Atlantic**

*Yuhji Yamamoto[1], Hiroto Fukami[1,2], Wakana Taniguchi[1], Peter C. Lippert[3] (1.Center for Advanced Marine Core Research, Kochi University, 2.Sanyo Techno Marine Co., Ltd., 3.Department of Geology and Geophysics, University of Utah)

[SEM18-P05] The Gauss-Matuyama polarity transition record from the Plio-Pleistocene marine sequence of the Mera Formation, Chikura Group, in the southernmost part of the Boso Peninsula

*Makoto Okada[1], Yosuke Hiraoka[2], Daisuke Hasegawa[2] (1.Department of Earth Sciences, Faculty of Science, Ibaraki University, 2.Graduate School of Science and Engineering, Ibaraki University)

[SEM18-P06] Holocene paleomagentic secular variation recorded in sediments from Lake Tazawa in Akita Prefecure, Northeast Japan

*Ryo Yasuda[1], Akira Hayashida[1], Kazuyoshi Yamada[2], Hiromi Matsuoka[3], Makoto Okamura[3], Daizo Ishiyama[4] (1.Doshisha University, 2.Museum of Natural and Environmental history, Shizuoka, 3.Kochi University, 4.Akita University)

[SEM18-P07] Geomagnetic excursions observed in Lake Suigetsu varved sediments during the latest stage of the last glacial period

*Shota Tanabe[1], Masako Miki[1], Masayuki Hyodo[2], Takeshi Nakagawa[3], Ikuko Kitaba[3], Keitaro Yamada[3], Junko Kitagawa[4], Suigetsu 2014 Project Members[5] (1.Kobe University, 2.Research Center for Inland Seas, Kobe University, 3.Ritsumeikan University, 4.Fukui Prefectural Satoyama-Satoumi Research Institute, 5.www.suigetsu.org)

[SEM18-P08] Geo-electromagnetic research at a spreading center of a divergent plate boundary in Afar depression, Ethiopia

*Naoto Ishikawa[1], Ryokei Yoshimura[2], Tesfaye Kidane[11], Shin-ichiro Higashino[3], Shin-ichi Kagashima[4], Nobutatsu Mochizuki[6], Ameha A. Muluneh[5], Kirika Kitagawa[4], Mamoru Kadoya[7], Noriaki Obara[10], Yo-ichiro Otofuji[9], Minoru Funaki, Tetsu Kogiso[1], Masakazu Fujii[8] (1.Graduate School of Human and Environmental Studies, Kyoto University, 2.Disaster Prevention Research Institute, Kyoto University, 3.Graduate School of Engineering, Kyushu University, 4.Yamagata University, 5.Addis Ababa University, 6.Kumamoto University, 7.X-TREME COMPOSITE JAPAN, 8.National Institute of Polar Research, 9.Japan Geochronology Network, 10.Robotista, 11.University of KwaZulu Natal)

[SEM18-P09] Verification of reducitive chemical demagnetization effect on the sedimentary rocks from the Kokumoto Formation, Kazusa Group, Boso Peninsula

*Takahiro Kitamura[1], Makoto Okada[1], Yuki Haneda[1], Chisato Anai[2], Hidetoshi Shibuya[2] (1.Ibaraki University, 2.Dep't Earth & Env. Sci., Kumamoto Univ.)

[SEM18-P10] Hole surface survey monitoring test using by rock magnetic analysis

*Noriko Kawamura[1], Naoto Ishikawa[2] (1.Japan Coast Guard Academy, 2.Graduate School of Human and Environmental Studies, Kyoto University)

[SEM18-P11] Rock magnetic measurements of Miocene dikes at the western margin of the Shitara Igneous Complex, central Japan

*Kohei Yamamoto[1], Hiroyuki Hoshi[2] (1.Graduate School of Education, Aichi University of Education, 2.Aichi University of Education)

[SEM18-P12] Eliminating spurious magnetic phases of sedimentary rocks using reductive chemical treatments – A thermomagnetic experiment study on the Upper Cretaceous Yezo Group-

*Chisato Anai[1], Hidetoshi Shibuya[1], Nobutatsu Mochizuki[1] (1.Kumamoto University)

[SEM18-P13] Rock-magnetic studies on seafloor hydrothermal deposits in the Okinawa Trough

*Chie Kato[1], Masao Ohno[1], Tadahiro Hatakeyama[2], Jun-ichiro Ishibashi[3], Shuhei Totsuka[4], Kazuhiko Shimada[3] (1.Department of Environmental Changes, Faculty of Social and Cultural Studies, Kyushu University, 2. Information Processing Center, Okayama University of Science, 3.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 4. Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University)

[SEM18-P14] Rock-magnetic study of fresh dunite in the Horoman peridotite complex, Hokkaido, Japan

*Nobutatsu Mochizuki[1], Satoko Ishimaru[1], Shoji Arai[2] (1.Department of Earth and Environmental Science, Faculty of Advanced Science and Technology, Kumamoto University, 2.Department of Earth Sciences, Faculty of Science, Kanazawa University)

[SEM18-P15] Improvements of sensitivity and utility in the scanning superconducting quantum interference device (SQUID) microscope

*Yusuke Kubota[1], Joseph Kirschvink[2,1], Isaac Hilburn[2], Jennifer Buz[3], Atsuko Kobayashi[1,2], Chie Kato[4]
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Analyzing the early 19th cenytury's geomagnetic declination in Japan from Tadataka Inoh's Santou-Houi-Ki the 13th roeport.

*Motohiro Tsujimoto[1], Akitoshi Omotani[2]

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The Santou-Houi-Ki is a national treasure of Japan 67 volumes magnetic survey ledger recorded by cartographer Tadataka Inoh in 1800 to 1816,consist of approximately 200,000 magnetic compass land survey azimuth data accuracy of 0 degree 5 min, from the coast of eastern Hokkaido to Yakushima Island in Western Japan. I restarted the analysis stopped after only one analysis in 1917,which done about the magnetic compass survey azimuth data at known position of the retirement home of Tadataka Inoh at Fukagawa in Edo (Tokyo) in 1802-1803,by interdisciplinary simultaneous analysis across geomagnetism, survey science, historical cartography and local history.
(1)Interdisciplinary simultaneous analysis: We can increase precise evidence to verify the real azimuth, geomagnetic declination and the reference point where magnetic compass survey was executed, or survey target points recorded in the Santou-Houi-Ki, than traditional way of study separated in each field.
(2) Procedure of analysis: Use the recreation software of scenery and digital map of GSI Japan Chiriin Chizu to know the latitude and longitude accuracy sec of particular survey target points, and the outline position of survey reference point to grasp the outline of each real azimuth from the survey reference point to survey target points. Geomagnetic declination=Real azimuth-Magnetic compass survey azimuth recorded in the Santou-Houi-Ki. Calculate backward the precise position of the survey reference point should be adjusted to the position in accuracy 0.001sec.in latitude and longitude, where all of geomagnetic declination unit of 0.01sec. Calculate from the magnetic compass survey azimuth to each different targets at the reference point are approximately equal to each other. Calculate the average value of each declination unit of 0.001sec.and express it as the geomagnetic declination unit of 1min.on the day and point Tadataka Inoh's magnetic compass survey was executed. To use the consecutive formula of Excell for speed up and Keep accuracy. If it possible to go to the field of the survey reference point, confirm the real scenery and the longitude and latitude by GPS transmitter and recalculate the value of geomagnetic declination.
(3) The outline of isogonic line in Japan archipelago and the distribution of the declination in every 15 min in western Japan coast in those days. begin to appear. Compare the isogonic line of declination in those year's Japanese archipelago by analysis of The Santou-Houi-Ki,with the Historical Magnetic Declination map by NOAA(1800,1805,1810,1815)is the NOAA's pace of variation West is almost 5 years later than the analysis of the Santou-Houi-Ki in western Japan. (4)However, from the analysis of Santou-Houi-Ki, we can recognise the magnetic declination supposed as the local geomagnetic declination anomaly in southern coast of eastern Hokkaido, some part of Noto Peninsula, Mt. Asama in Ise, Nobeoka city in Kyushu Island etc. and revealed the long western coast of Tsushima island etc.,impossible to drew in Historical Declination Viewer by NOAA. The analysis is developed from the coast area of Japanese archipelago to the inland area of Honshu island. (5)It is able to restore the precise position of survey reference points where Tadataka Inoh's magnetic compass survey was executed the accuracy of less than sec in latitude and longitude ,valuable in local history. It is so accurate as impossible to achieve by other way of study.(6)It is able to change Japan as the concentrated area of data in early 19th century from insufficient area of data and supply data to north east Asia.
Total number of analyzed points exceeded 229. (7)We started the discussion to compile those analysis to the database available to Archeomagnetiism Data base, or NOAA’ s Historical Declination Viewer.In this year I will focus on between Niigata prefecture including Sadogashima island from Ishikawa prefecture.

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Keywords: geomagnetic declination , Tadataka Inoh, Santou-Houi-Ki, reference point , target point, interdiciplinary

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Forecasting geomagnetic secular variation based on magnetic diffusion at the core-mantle boundary

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The International Geomagnetic Reference Field (IGRF) is a standard mathematical description in terms of spherical harmonic coefficients, known as the Gauss coefficients, for the Earth's main magnetic field and its secular variation, updated every five years. In the next IGRF revision, the 13th generation of IGRF (IGRF-13), the Definitive Geomagnetic Reference Field for 2015 (DGRF-2015), the IGRF for 2020 (IGRF-2020), and the Secular Variation (SV) from 2020 to 2025 (SV-2020-2025) are to be released. We are planning to submit a model of SV-2020-2025 using our strong points, such as geodynamo numerical simulations, data assimilation, and core surface flow modeling.

Forecasts of geomagnetic SV are likely to require geomagnetic secular acceleration (SA), which can be expressed in terms of core fluid velocity and acceleration in the first time derivative of induction equation. In fact, Whaler and Beggan (2015) pointed out that forecasts of the Earth's main magnetic field and its temporal changes are improved for a model in which fluid velocity and acceleration are included. They also suggested that the quality of forecasts might be lowered for a period during which a geomagnetic jerk, a sudden temporal change in the geomagnetic acceleration, occurs. On the other hand, however, Fournier et al. (2015) pointed out that core flow acceleration could be neglected to forecast SV through data assimilation. Thus it is important to clarify the necessity of employing core flow acceleration.

In this presentation, we investigate whether or not geomagnetic SA is of importance to forecast geomagnetic SV, taking into account geomagnetic jerks occurred in 2003 and 2007 (e.g. Olsen and Mandea 2007; Chulliat et al. 2010). We assume that geomagnetic SV is caused only by magnetic diffusion at the core-mantle boundary, because core flow should vanish at the core surface on the no-slip boundary condition. We also show that the present method of forecasting the Earth's main magnetic field and its SV is consistent with simple analytical extrapolation of geomagnetic field. In other words, such simple extrapolation is based on a physical phenomenon of magnetic diffusion.

Keywords: IGRF, geomagnetic secular variation, magnetic diffusion

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Candidate models of IGRF13-SV from Japanese team

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International Geomagnetic Reference Field (IGRF) and its secular variation models are open to public every five years. Next IGRF models, the Gauss coefficients to represent the spatial distribution of the field at epoch 2020.0 and its secular variation (first time derivatives) in the period from 2020.0 to 2025.0, will be determined and published around December, 2019, by Working Group of IAGA V-MOD. The IGRF and its secular variation models are determined based on candidate models submitted by research groups for Working Group V-MOD. We plan to submit a candidate secular variation model to contribute for determining IGRF13-SV.
Prediction of the main geomagnetic field is necessary to obtain a candidate model for IGRF and its secular variation. Although purely statistical prediction, which had been a usual procedure in the past, can be a possible method, we employ physics-based modeling for the prediction. Since the parameters used for geodynamo calculations are not "realistic" values for the Earth's core, it is not appropriate to take geodynamo solutions as they are for the predictions. Nevertheless, it is possible to select parameter set and appropriate normalizing time-scales to obtain modeled magnetic field that is similar to the geomagnetic field. In this presentation, we are going to show candidate models of secular variation obtained by geodynamo data assimilation with discussions on the time-scales, the method of assimilation, and data-set employed for the modeling.

Keywords: IGRF, geodynamo modeling, geodynamo data assimilation

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Preliminary report on the paleointensity variation during 38-50 Ma deduced from the marine sediments recovered from the northwest Atlantic

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Variations of the intensity of the paleomagnetic field (paleointensity), which provide clues about the evolution of the geodynamo, are recorded in rocks and sediments. Marine sediments give relative paleointensity (RPI) continuously in time. For the period of 0-2 Ma global RPI stacks [1][2] have been reported based on numerous regional RPI records. For the period of 2-3 Ma there have been increasing number of regional RPI records [3][4]. However, published RPI records older than ~3 Ma are very limited in time and space: 14.5-18.5 Ma [5], 17.5-26.5 Ma [6], 23-41 Ma [7] from the equatorial Pacific; 23-34 Ma from the South Atlantic [8]. We have conducted a paleomagnetic study on the marine sediments recovered in the northwest Atlantic to extend our knowledge of the RPI variation in further geologic past, and report on the preliminary RPI results for the period of about 38-50 Ma.

Integrated Ocean Drilling Program (IODP) Expedition 342 recovered hemipelagic sediment drifts from Sites U1403 and U1408 in the northwest Atlantic, off the coast of Newfoundland [9]. Piston cores of the two sites were subjected to a series of the paleomagnetic measurements including analyses of natural, anhysteretic, and isothermal remanent magnetizations (NRM, ARM, and IRM). Excluding the intervals showing signs of probable dissolution of primary magnetic minerals (low ARM intensity intervals) and inhomogeneous magnetic grain sizes (mainly for low ARM/IRM intervals), RPIs were estimated based on ratios of NRM/ARM and NRM/IRM.

Considering age models of the studied cores [10][11], the resultant RPI records cover the Chrons 18 (38.5-41.1 Ma), 19 (41.1-42.9 Ma), 20 (42.9-46.4 Ma), 21r (47.8-48.6 Ma), and 22n (48.6-49.3 Ma). These records are characterized by RPI minima always at chron boundaries and large fluctuations between highs and lows during each chron. Such charactersistics are commonly recognized in the published RPI records back to 41 Ma [1-8]; this is first record to show that they persist at least since 49.3 Ma.

For the Chron 18 interval, we obtained RPI results from both sites, which are approximately 380 km apart (Figure 1). Our results show common features, including RPIs that are generally high during C18n.2n (39.6-40.0 Ma) and low during C18r (40.0-41.1 Ma). Prominent RPI lows, which appear to be almost equivalent to the RPI minima at other chron boundaries (*i.e.*, during Chrons 19, 20, 21r, and 22n), are also commonly recognized at ~40.5 Ma. We suggest that the RPI lows might be related to a failed geomagnetic reversal.

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The Gauss-Matuyama polarity transition record from the Plio-Pleistocene marine sequence of the Mera Formation, Chikura Group, in the southernmost part of the Boso Peninsula

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We aim to reconstruct a detailed geomagnetic field variation during the Gauss-Matuyama polarity transition which has a fewer study cases compare to the Matuyama-Brunhes boundary, we have conducted a paleomagnetic study on the Plio-Pleistocene marine sequence of the Mera Formation, Chikura Group.

In the section of the layer thickness of 36.4 m in the middle part of the cloth layer containing the G-M boundary, samples for palaeomagnetic measurements were placed at intervals of about 5 to 30 cm in the layer intervals of 12.1 to 19.1 m, at intervals of about 1 m in the layer intervals of 25.4 to 36.4 m , From a total of 72 layers. As a result of rock magnetometry measurements, the change in the magnetic minerals which is obvious lower and upper than the layer thickness of 19.1 m was caught. In addition, the transition of the magnetization direction from the positive magnetic pole to the reverse magnetic pole was captured in the layer intervals of 12.5 to 13.3 m from the restored VGP fluctuation. Since the relative paleomagnetic intensity at that time attenuates to about 1/4 of the normal time, we considered that the G-M boundary was recorded in this level. The restored VGP fluctuation can be confirmed to be stagnant in the mid latitudes after reversal. This is consistent with the record of the Gauss-Matsuyama boundary restored by Ohno et al. (2012).

Keywords: Gauss-Matuyama boundary, Chikura Group

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Holocene paleomagentic secular variation recorded in sediments from Lake Tazawa in Akita Prefecure, Northeast Japan

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We conducted a paleomagnetic study of three piston-core samples from Lake Tazawa in Akita Prefecture, aiming at reconstruction of the paleomagnetic secular variation in Northeast Japan. An age-depth model based on radiocarbon dating shows that the core samples cover the last 7500 cal year BP in the Holocene. Measurements of natural remanent magnetization (NRM) and anhysterresis remanent magnetization (ARM) were carried out on U-channel samples by a pass-through method with a 2G-Enterprises superconducting rock magnetometer. Then, we made deconvolution of the pass-through data by using the software UDECON (Xuan and Oda, 2015), which searches the optimum result in the ABIC-minimizing single smoothness-parameter scheme assuming smoothness in variation of the sediment magnetization. Low-field magnetic susceptibility of the U-channel samples was also measured by a pass-through method and deconvolved using the software, which we developed in two schemes, first assuming a single smoothness parameter for the entire sample (mono-decon) and then introducing an additional parameter for a specific interval (dual-decon). The program “dual-decon” enables us to assign the second hyper-parameter for the interval with a sharp susceptibility peak such as a tephra layer and an event layer. Experiments using a simulated continuous sample made by connecting discrete cubic samples (“cube-train”), which contains the B-Tm tephra layer, showed that the dual-decon produces the better result which is consistent with the discrete measurements rather than the mono-decon. It is suggested that the noise originated from a sharp increase could be reduced by introducing the second smoothness-parameter in the deconvolution process. Principal component analysis of the alternating-field demagnetization data after the deconvolution by UDECON revealed existence of characteristic magnetic components, which can be regarded representing the past geomagnetic field. In particular, the declination after 3,000 cal yr BP shows consistent variations between the cores. This variation also shows a good similarity with a global archaeomagnetic secular variation model, ARCH3k.1, and the paleomagnetic record from Lake Biwa (BIWA SV-3), implying importance for reconstruction of the paleosecular variation in Northeast Japan. On the other hand, estimation of relative paleointensity was difficult, mainly due to ununiformity of concentration and grain-size of magnetic minerals, suggested by variation of the ARM, the low-field susceptibility and the ARM susceptibility/susceptibility ratio.

Keywords: paleomagnetic secular variation, Holocene, deconvolution

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Geomagnetic excursions observed in Lake Suigetsu varved sediments during the latest stage of the last glacial period

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A geomagnetic excursion is a brief event that the geomagnetic field direction deviates largely from a normal one, generally lasting for less than two thousand years. The relative paleointensity data stack Sint-800 revealed that the excursions during the Brunhes Chron occurred when the dipole magnetic field strength decreased below 50% of the present one. However, some previous studies report some geomagnetic excursions may be unrelated to weakening of the geomagnetic field. We conducted paleomagnetic analyses of the Lake Suigetsu varved sediments in order to detect unknown excursions during the past ca. 20 ka.

We analyzed the Fukui-SG14 core collected in 2014 from Lake Suigetsu. Paleomagnetic analyses were conducted on LL-channel sections of 1 m length with a cross section of 2 cm ×2 cm, with stepwise alternating field demagnetizations at depth intervals of 1 cm (about 14 years in time) over a composite-depth range from 900 cm - 2100 cm (correlation model version 08 May 2016). Principal component analysis was performed on the demagnetization data at 852 depth levels, and positions of virtual geomagnetic poles (VGPs) were calculated. As a result, we found three geomagnetic excursions including successive directions with VGPs lower than 45˚N, between 1700 cm and 2000 cm in depth. The three excursions are tentatively named A, B, and C in the descending order. The detailed chronology of the Fukui-SG14 based on the high-resolution correlation with the SG06 age model provides their mid-ages (durations) are about 15.3 $SG06_{2012}$ kyr BP (about 370 yr), 17.7 $SG06_{2012}$ kyr BP (about 130 yr), and 19.4 $SG06_{2012}$ kyr BP (about 380 yr), respectively. The intensities in the geomagnetic excursions we observed do not decrease.

We also conducted stepwise thermal demagnetizations with some samples from the excursion zones. The results confirmed presence of the excursions.

The thermomagnetic analyses and isothermal remanent magnetization (IRM) acquisition experiments show that the main magnetic carriers are magnetite and greigite.

Keywords: geomagnetic excursion

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Geo-electromagnetic research at a spreading center of a divergent plate boundary in Afar depression, Ethiopia

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In order to clarify the formation process of magnetic stripes and structure under a sea-floor spreading center at the divergent plate boundary, we are performing an on-land geo-electromagnetic research project in Afar Depression, Ethiopia, where we can investigate into a subaerial sea-floor spreading center directly. We will introduce the outline of our project and report preliminary results form 2016-2018 field surveys and data analyses.

Keywords: divergent plate boundary, sea-floor spreading, maginetic anomaly, geo-electromagnetic research, small unmanned aircraft

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Verification of reducitive chemical demagnetization effect on the sedimentary rocks from the Kokumoto Formation, Kazusa Group, Boso Peninsula

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The Matuyama-Brunhes boundary (M-B boundary) has been confirmed in the Chiba composite section which is the lower-middle Pleistocene boundary GSSP candidate site composed of the Kokumoto formation, Kazusa Group, and paleomagnetic studies have been actively conducted. During a geomagnetic polarity transition, since the geomagnetic intensity remarkably decreases, the primary magnetization is generally recorded very weakly in sedimentary rocks. In the Kokumoto formation, it is cosidered that chemical remanent magnetization due to the magnetic mineral made secondarily is responsible for the secondary magnetization, and it is impossible to separate the primary and the secondary magnetizations by alternating field demagnetization (AFD). On the other hand, in the thermal demagnetization (TD), the secondary magnetization is successfully demagnetized by heating at 400 ℃ or more, but due to the thermal decomposition of magnetic minerals, additional magnetic minerals are newly generated during demagnetization, so that the relative paleointensity can’ t be restored. Okada et al. (2017) restored magnetostratigraphy by combination demagnetization (TD in 300 ℃ + progressive AFD) to avoid thermal decomposition of magnetic minerals. However, minerals that cause secondary magnetization remain in the specimen, and there is a possibility that it may hinder the restoration of the primary magnetization as noise. Therefore, in this research we attempted chemical removal of minerals responsible for secondary magnetization by reductive chemical demagnetization (RCD), a method established by Anai et al. (2017).
In this study, RCD was performed on 4 samples collected between the Byk-E and Byk-A key tephra beds, in which the directional polarity reversal corresponding to the M-B boundary was confirmed in Okada et al. (2017). For RCD, an etchant solution whose pH was adjusted with sodium bicarbonate in a 5 % ascorbic acid aqueous solution was used. Thermomagnetic measurements in air were carried out on samples for both of subjected and not subjected to RCD and the sample not subjected to RCD. RCD s were performed by dropping a solution onto two samples out of four samples and immersing the remaining two samples in a solution. Then, thermomagnetic measurements were carried out again on samples for both of subjected and not subjected to RCD. In all the samples not subjected to RCD, the saturation magnetizations which showed gradual decreasing with increasing temperature rose greatly at around 400 ℃. On the other hand, in samples subjected to RCD, it was observed that the increase in saturation magnetization at around 400 ℃ was suppressed. These results suggest that minerals related to thermal alteration is eluted by RCD, and dripping is better than dipping as a method of RCD.

Keywords: Reductive chemical demagnetization, chemical remanent magnetization, Matuyama-Brunhes boundary, Chiba composite section

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Hole surface survey monitoring test using by rock magnetic analysis

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For a successful criminal conviction to occur, it is essential to locate forensically important evidences which are disposed in soil. In this study, we attempted rock magnetic method as a forensic search tool to detect evidences in soil. A 2.5 m long survey line was provided in the campus ground of Japan coast guard academy, 0.1 m×0.2 m×0.7 m sized hole was created and was buried into the sand soil. Magnetic susceptibility (MS) was measured using by a ZH instruments magnetometer every 0.1 m along the line, and was measured six times at every position. MS indicates relative higher values at the disturbed ground. A core sample in 7 cm length was collected using by a soil sampler at around the disturbed ground. The soil core was consisted of silty sand with granule, and the grain size of soil increases with burial depth. Dried soil samples were packed into 1 cm^3 plastic cubes every 1 cm from the core. Rock magnetic measurements, MS, anhysteretic remanent magnetization (ARM), isothermal remanent magnetization (IRM) were conducted for the cube samples. The powder soil samples of isothermal magnetization (M_{rs}), saturation magnetization (M_s), coercivity (H_c), and remanence corecivity (H_{cr}) were measured. MS shows a peak at 2 cm in depth. Values of ARM and IRM gradually decrease with depth. It is implied that the relative high MS of disturbed ground was caused by the mixed lower soil. In order to identify magnetic minerals in the soil samples, thermomagnetic analysis (Js-T) was performed on four samples which are collected from the soil core of surface (0-0.2 m), middle (0.3-0.5 m) and deep parts (0.6-0.7 m) and the surface soil at the disturbed ground. All samples indicate declines of Js-T curves at 580°C and 680°C. A slight inflection in Js-T curves at around 300°C -400°C is also recognized, the presence of maghemite and hematite is thus suggested. M_{rs}/M_s and H_{cr}/H_c values of the core samples are plotted in the pseudo-single domain (PSD) region for (titano-) magnetite on the Day plot, and indicate that grain size of magnetic minerals downward decrease. The values of disturbed ground are located the central part of all samples which are implied that the mixed lower soils were contributed. The MS peak have been recognized after eight months although the disturbed ground covered by weeds and the hole is invisible. This result proves that MS can detect the location of disturbed ground over eight months post-disturbance. It is suggested that MS is effective for detecting the location of disturbed ground.

Keywords: forensic science, rock magnetism, environmental magnetism

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Rock magnetic measurements of Miocene dikes at the western margin of the Shitara Igneous Complex, central Japan

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We performed rock magnetic measurements for Miocene andesite dikes intruding granitic and metamorphic rocks of the Ryoke belt of the Mikawa district, Aichi Prefecture, in order to reveal the rock magnetic characteristics of the dikes. We collected andesite samples both from dark gray, apparently fresh rocks and gray to white, slightly to severely altered rocks. Thermomagnetic (magnetic susceptibility vs temperature) analysis and thermal demagnetization of composite isothermal remanent magnetization (IRM) yielded data showing that both titanomagnetite and pyrrhotite are contained in the majority of the samples. At one site, we found that pyrrhotite is the only magnetic mineral carrying the remanent magnetization. The pyrrhotite that we identified at almost all sampling sites is thought to have been precipitated as a secondary mineral by hydrothermal alteration, or formed as a primary mineral in a reductive condition during solidification of magmas in the host meta-sedimentary rock.

Keywords: Shitara Igneous Complex, dikes, paleomagnetism, rock magnetism, magnetic minerals

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Eliminating spurious magnetic phases of sedimentary rocks using reductive chemical treatments –A thermomagnetic experiment study on the Upper Cretaceous Yezo Group-

*Chisato Anai[1], Hidetoshi Shibuya[1], Nobutatsu Mochizuki[1]

1. Kumamoto University

Sedimentary rocks often have secondary components of chemical remanent magnetizations (CRM) during post-depositional processes, lithification, diagenesis, and/or later chemical events, in addition to the primary detrital remanent magnetization (DRM). These secondary components are carried by secondarily formed minerals of iron-oxides, hydroxides, and/or sulfides. These secondary minerals are produced by Fe-ions contained in pore water and/or sedimentary rocks itself. Therefore, secondary CRM carriers precipitate in the space between mineral particles and/or the voids of the sedimentary rocks, since these parts are reached first by pore water from outside of the samples. The secondary minerals often have a large thermal alteration during thermal demagnetization experiments. Thermal alterations at high temperature steps often introduce large laboratory-CRM, which masks the primary component. Those CRM acquired in the furnace could be reduced by removing secondary magnetic minerals using reductive chemical demagnetization (RCD) beforehand (Anai et al., 2018). In this study, we show the results of rock magnetic and paleomagnetic experiments of samples from the Upper Cretaceous Yezo Group, in order to see whether the RCD is effective reducing such spurious magnetic components.
A pair of chip samples were prepared from paleomagnetic cores. One of the chip samples was subjected to RCD, and the other remained intact. The RCD is performed by dipping the chip sample in the etchant for 72 hours (recipe: Ascorbic acid 5%, buffered by sodium bicarbonate, and adjusted to pH= ~5.6, ORP= -150 to -50 mv). Strong-field thermomagnetic analyses were conducted on both chip samples with and without the RCD. Thermomagnetic curve of the samples without RCD show 4 types of thermal alternation behavior. As a characteristic example of the result Type-C is as follows: magnetization (Js) increases around 400˚C. The increase of Js makes a peak at 450˚C and then Js gradually decreases to zero at 580˚C. Abrupt increases of Js around 450˚C was not observed for the RCD sample, while the Js drops at 150˚C and 580˚C are the same as those observed for the samples without RCD. These results suggest that the iron-containing minerals, which changed to minerals carrying CRM around 450˚C, had been effectively removed by RCD. The results suggested that the RCD pretreatment may suppress thermal alteration of sedimentary rocks. This approach seems to have potential for reducing spurious secondary magnetic components effectively, though the relation between the thermal alteration and spurious magnetic components is not well understood.

Keywords: Yezo Group, Reductive chemical demagnetization

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Rock-magnetic studies on seafloor hydrothermal deposits in the Okinawa Trough

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Investigation of the mineral assemblage of seafloor hydrothermal deposits are crucial for understanding its formation environment and process. Rock-magnetic measurements of the deposits are quick and effective to detect magnetic metal sulfides which are sensitive to the environment. We report our results of rock-magnetic measurements conducted on sulfide ores from seafloor hydrothermal deposits in the Okinawa Trough. One sample is a sulfide ore of chimney structure collected from hydrothermal mound in the Noho Site and others are sediment core samples drilled at the Izena Hole.
X-ray diffraction (XRD) measurements and chemical analyses indicate that the chimney structured ore mainly consist of pyrrhotite and a Cu-Fe-S sulfide. Crystal structure of the Cu-Fe-S sulfide is similar to that of sphalerite and its chemical composition is close to $CuFe_2S_3$. From these characters, $CuFe_2S_3$ isocubanite is the candidate for the Cu-Fe-S sulfide.
Since the magnetic properties of $CuFe_2S_3$ isocubanite were rarely found in the literature, we first conducted low-temperature magnetometry measurements and magnetic hysteresis measurements of isocubanite. Isocubanite was synthesized by heating a cubanite sample (from Henderson No.2 mine, Chibougaman, Qubec, Canada) at 300 ℃ in vacuum (e.g. Sawada et al., 1962; Nenasheva and Kravchenko, 2015). Results of the magnetic measurements showed that isocubanite is weakly ferromagnetic at room temperature, and undergo a magnetic transition to relatively strong ferromagnetic at ~100 K. Saturation magnetization was 0.09 Am^2/kg at room temperature and 0.4 Am^2/kg at 50 K. Similar magnetic measurements were performed on the Cu-Fe-S sulfide in the chimney ore which was magnetically separated from pyrrhotite. The Cu-Fe-S sulfide was paramagnetic at room temperature and became ferromagnetic at below ~100 K. Saturation magnetization at 50 K was ~20 Am^2/kg. Such strong magnetization and sharp magnetic transition at low temperature is inconsistent with the behavior of isocubanite, but rather comparable to that of $Cu_{1-\varepsilon}Fe_{3+\varepsilon}S_4$ 'new phase' reported by Wintenberger et al. (1994) as an ageing product of isocubanite. Results of our magnetic measurements indicate that 'new phase' is a solid solution which includes $CuFe_2S_3$ composition.
Some of the sediment core samples contain a Cu-Fe-S sulfide with similar XRD pattern and chemical composition to that found in the chimney ore. Those sediment core samples also show a magnetic transition at ~100 K. Intensity of the magnetization at low temperature could be explained by assuming that the Cu-Fe-S sulfide in the sediment core samples is isocubanite, based on rough estimate of mineral proportion from XRD.

Keywords: Hydrothermal deposits, Cu-Fe-S sulfide, Low-temperature magnetometry

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Rock-magnetic study of fresh dunite in the Horoman peridotite complex, Hokkaido, Japan

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1. Department of Earth and Environmental Science, Faculty of Advanced Science and Technology, Kumamoto University, 2. Department of Earth Sciences, Faculty of Science, Kanazawa University

Magnetic anomalies observed on Earth are originated from remanent/induced magnetizations of the crust and probably those of the uppermost lithospheric mantle. For the lithospheric mantle, rock-magnetic data were mostly reported from serpentinized peridotites although some data were available for fresh mantle xenoliths from a few volcanoes. Since fresh peridotite samples are relatively scarce, the original magnetic properties of peridotite are not well studied. Rock-magnetic studies on fresh peridotites are required to characterize magnetization of the lithospheric mantle. In the present study, we report rock magnetic properties of fresh dunite samples and discuss the possibility of a source of magnetic anomaly on Earth and the other planets. The samples used in this study are collected from spinel-rich dunite-wehrlite (SDW) suite, mainly composed of clinopyroxene-bearing dunite, in the Horoman peridotite complex, Hokkaido, Japan (Takahashi, 1991). Fresh dunite samples were collected from a 20 m wide outcrop of SDW suite. Minute magnetite inclusions, which show elongated rod-like shapes, were observed in olivine grains under the microscope. It should be noted that the elongated magnetite inclusions are not associated with serpentinization. Densities of the samples mostly ranged in 3250-3350 kg/m^3, which correspond to typical values of fresh peridotite. A diagram of natural remanent magnetization (NRM) versus susceptibility shows that the data of the samples are clearly different from the data reported from serpentinized peridotites. Several samples have NRM values of 1-20 A/m, which are comparable to NRM values of volcanic rocks. A dunite layer of such strong NRM could be a potential source of magnetic anomalies.

Keywords: magnetization, dunite, Horoman peridotite complex

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Improvements of sensitivity and utility in the scanning superconducting quantum interference device (SQUID) microscope

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1. Tokyo Institute of Technology, 2. California Institute of Technology, 3. Northern Arizona University, 4. Kyushu University

Superconducting quantum interference device (SQUID) microscopes have been used for mapping the distribution of ferromagnetic materials in a variety of industrial, biological, and geological materials. The advantage of the SQUID microscope is the wide dynamic range and spatial resolution down to the 25 μm scale, as well as the ability to quantify the direction and intensity of extraordinarily tiny magnetic dipoles. However, a major drawback of earlier versions of this instrument has been the need to cool the superconducting sensors with liquid helium and nitrogen, which limits the system's utility and drives up maintenance costs. One previous instrument (at Caltech) incorporated a closed-cycle pulse-tube cryocooler and managed to achieve good sensitivity by averaging precisely over one pulse cycle to remove the periodic magnetic signal from the pulse tube ferrite chain. In this study, we report a new design of SQUID microscope at TokyoTech that improves substantially on this. First, a large-volume μ-metal shielded room provides an environment with low spatial magnetic gradients, although it does allow ~ 5 nT low-frequency signals from local train lines to penetrate. Next, the pulse-tube is encased in a superconducting shield made of Pb, lowering the noise from that source. Finally, we placed a second SQUID sensor, parallel to the axis, ~4 cm from the first and calibrated it to correct for background fluctuations. The final system is approximately 5-10 times more sensitive than the previous configuration and is being applied to a variety of biological and single-crystal rock magnetic studies.

Keywords: SQUID microscope, Rock magnetism

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[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT20] Property and role of liquids inside terrestrial planets

convener:Tatsuya Sakamaki(Department of Earth Science, Tohoku University), Yoichi Nakajima(Kumamoto University, Priority Organization for Innovation and Excellence), Chairperson:Tatsuya Sakamaki(Tohoku University), Yoichi Nakajima(Kumamoto University)

Liquids of silicates and metals inside of terrestrial planets play important role in the physical, chemical, and thermal evolutions of planets. This session aims at understanding the physical and chemical properties of liquids from shallower to deep parts of terrestrial planets, which are strongly related to the long history of those planets from the planetary accretion to the present-day dynamics. In addition, we call for presentations by researchers from various backgrounds of geochemical, experimental, theoretical/computational, and seismic/geodynamical ones, who investigate the physical and chemical properties of liquids and the behaviors and roles inside of terrestrial planets. Relevant topics include, but are not limited to, partial melting and melt extraction, liquid-solid partitioning, high pressure experiments on melts, and seismic detections of mantle melts and outer core anomaly.

10:45 AM - 11:15 AM JST | 1:45 AM - 2:15 AM UTC

[SIT20-01] Ultrahigh pressure structure change in SiO_2 glass with coordination number >6

★Invited Papers

*Yoshio Kono[1], Yu Shu[2], Curtis Kenney-Benson[2], Yanbin Wang[3], Guoyin Shen[2] (1.Geodynamics Research Center, Ehime University, 2.Argonne National Laboratory, 3.The University of Chicago)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SIT20-02] **Scaling pseudotachylytes from the lab to the field**

*Thomas P. Ferrand[1], Alexandre Schubnel[2], Nadège Hilairet[3], Loïc Labrousse[4], Stefan Nielsen[5] (1.Earthquake Research Institute, 2.Ecole Normale Supérieure, Paris, France, 3.Unité Matériaux et Transformations, Université de Lille, France, 4.Sorbonne Université, Institut des Sciences de la Terre Paris, France, 5.Department of Earth Sciences, Durham University, United Kingdom)

11:30 AM - 12:00 PM JST | 2:30 AM - 3:00 AM UTC

[SIT20-03] *Ab initio* molecular dynamics study of atomic diffusion in covalent liquid under high pressure

★Invited Papers

*Satoshi Ohmura[1], Taku Tsuchiya[2] (1.Hiroshima Institute of Technology, 2.Ehime University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SIT20-04] **Pressure-induced structural change in magnesium silicate melts**

*Toshiaki Iitaka[1], Nguyen Van Hong[2] (1.RIKEN, 2.Hanoi University of Science and Technology)

Ultrahigh pressure structure change in SiO_2 glass with coordination number >6

*Yoshio Kono[1], Yu Shu[2], Curtis Kenney-Benson[2], Yanbin Wang[3], Guoyin Shen[2]

1. Geodynamics Research Center, Ehime University, 2. Argonne National Laboratory, 3. The University of Chicago

Possible existence of ultrahigh pressure structural change in silicate magma with the Si-O coordination number (CN) larger than 6 is one of the most important issues in understanding nature of silicate magmas at the Earth’s core-mantle boundary. However, structure of silicate magmas at the ultrahigh pressure conditions of the core-mantle boundary remain poorly understood, because of experimental challenges. Efforts have been made to investigate structure and/or properties of silicate glasses, as an analogue of silicate magma, at ultrahigh pressure conditions. Pioneering work by Murakami and Bass (2010) discovered a kink in the pressure dependence of shear-wave velocity in SiO_2 glass around 140 GPa, which was interpreted as evidence of ultrahigh pressure structural transition with the CN>6. However, no structural information is available under such ultrahigh pressure conditions. Our recent development of double-stage large volume cell combined with multi-angle energy dispersive X-ray diffraction opened a new way to investigate structure of oxide glasses under ultrahigh pressure conditions of >100 GPa. The new experiment revealed existence of ultrahigh pressure polyamorphism in GeO_2 glass with CN>6 (Kono et al., 2016). Our latest development further enhanced the structure measurement capability and we succeeded to measure structure of SiO_2 glass up to 120 GPa. Here we will show ultrahigh-pressure structural change in SiO_2 glass at the pressure conditions near the Earth’s core-mantle boundary.

Kono Y*, et al.* (2016) Ultrahigh-pressure polyamorphism in GeO_2 glass with coordination number> 6. *Proceedings of the National Academy of Sciences* 113(13):3436-3441.

Murakami, M., & Bass, J. D. (2010). Spectroscopic evidence for ultrahigh-pressure polymorphism in SiO_2 glass. *Physical review letters*, *104*(2), 025504.

Keywords: high pressure, SiO2 glass, magma, core-mantle boundary

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Scaling pseudotachylytes from the lab to the field

*Thomas P. Ferrand[1], Alexandre Schubnel[2], Nadège Hilairet[3], Loïc Labrousse[4], Stefan Nielsen[5]

1. Earthquake Research Institute, 2. Ecole Normale Supérieure, Paris, France, 3. Unité Matériaux et Transformations, Université de Lille, France, 4. Sorbonne Université, Institut des Sciences de la Terre Paris, France, 5. Department of Earth Sciences, Durham University, United Kingdom

Recent experimental and field results described high-pressure pseudotachylytes that formed in peridotite at mantle depth in similar pressure-temperature conditions. The pseudotachylyte is the rock originating from the solidification of the rupture-induced magma, often referred to as “frictional” melt, which transiently forms and aids sliding on the fault plane.
The pseudotachylyte thickness *a* scales with the relative displacement. The scaling law seems continuous over eight orders of magnitude from the laboratory to the field scale, for measured sliding varying from microns to meters. For magnitudes between -6 and 9, experimental and natural high-pressure faults show striking similarities.
In most lithologies, a kink is observed in the scaling law when the sliding and thickness reach 1 mm and 100 μm, respectively, i.e. Mw >1. This saturation of the pseudotachylyte thickness is due to the scale-depend efficiency of thermal diffusivity, and may also be affected by variations in magma mobility. Previous studies show a similar kink in seismological estimations of the fracture energy *G* as a function of *D*, for $D > 10$cm. The saturation of both *a* and *G* for large magnitudes would mark the transition from adiabatic to diffusive rupture propagation.
In addition, experimental micro-pseudotachylytes and experimental faults due to transformational faulting follow the same scaling law, which brings into light that transformational faulting could hide a transient melting stage.

Keywords: pseudotachylytes, melt, earthquakes, scaling, lubrication, laboratory analogues

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Ab initio molecular dynamics study of atomic diffusion in covalent liquid under high pressure

*Satoshi Ohmura[1], Taku Tsuchiya[2]

1. Hiroshima Institute of Technology, 2. Ehime University

Transport properties of covalent liquids under high pressure are very interesting in the sense that they show unexpected pressure dependence. For a number of covalent liquids, such as SiO_2, B_2O_3 and silicates abnormal behavior of the viscosity has been observed, i.e. the viscosity significantly drops with increasing pressure [1, 2, 3]. This anomalous behavior of the viscosity is considered to be related to the atomic diffusion in the liquids under pressure. It is, however, unclear how the rearrangement process of the covalent bonds is affected by compression. In order to explore the pressure dependence of microscopic diffusion mechanism in covalent liquids, we performed *ab initio* molecular dynamics simulations for liquid B_2O_3 and liquid basaltic aluminosilicate. These liquids has diffusivity maximum (viscosity minimum) under high pressure. We investigate the microscopic diffusion mechanism under high pressure. In the presentation, we discuss the origin of the anomalous pressure response of diffusivity from microscopic point of view.

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[2] V. Brazhkin, et al., Phys. Rev. Lett. **105**, 115701 (2010)
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Keywords: liquid , silicate, atomic diffusion, ab initio molecular dynamics

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Pressure-induced structural change in magnesium silicate melts

*Toshiaki Iitaka[1], Nguyen Van Hong[2]

1. RIKEN, 2. Hanoi University of Science and Technology

First principles calculation using periodic boundary conditions and density functional theory on high-performance computers have made great achievements in materials science under extreme conditions. However, many difficulties related to the dynamics and the size effects arise when it is extended to aperiodic systems such as liquids and amorphous solids under high temperature and high pressure [1]. Nonetheless the remarkable improvement of hardware capabilities and invention of new algorithms in the scope of the post-post-K computers will promote discoveries of new physics of such liquids.

Recently, a glass-glass transition of $MgSiO_3$ was observed at 88 GPa and room temperature using X-ray diffraction measurement under static compression in a diamond anvil cell[2]. It was suggested that this transition may be extended to a liquid-liquid transition of $MgSiO_3$ melt at higher temperatures and pressures, which corresponds to the perovskite post-perovskite (Pv-PPv) transition of $MgSiO_3$ crystal [3, 4].

Shock compression experiments for $MgSiO_3$ [5, 6] and Mg_2SiO_4 [7, 8]melts have been also performed making it possible to explore the structure and properties of liquids directly.

In this presentation, we report the results of molecular dynamics simulation of magnesium silicate melts under high temperature and high pressure using various simulation schemes such as Empirical Potential Molecular Dynamics (EPMD) [9]and First Principle Molecular Dynamics (FPMD) simulation[10] as well as Large-scale First Principle Molecular Dynamics (L-FPMD) simulation for a consistent understanding.

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Keywords: magnesium silicate melts, liquid structure, phase diagram

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[E] Poster | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_16

[S-IT20] Property and role of liquids inside terrestrial planets

convener:Tatsuya Sakamaki(Department of Earth Science, Tohoku University), Yoichi Nakajima(Kumamoto University, Priority Organization for Innovation and Excellence)

Liquids of silicates and metals inside of terrestrial planets play important role in the physical, chemical, and thermal evolutions of planets. This session aims at understanding the physical and chemical properties of liquids from shallower to deep parts of terrestrial planets, which are strongly related to the long history of those planets from the planetary accretion to the present-day dynamics. In addition, we call for presentations by researchers from various backgrounds of geochemical, experimental, theoretical/computational, and seismic/geodynamical ones, who investigate the physical and chemical properties of liquids and the behaviors and roles inside of terrestrial planets. Relevant topics include, but are not limited to, partial melting and melt extraction, liquid-solid partitioning, high pressure experiments on melts, and seismic detections of mantle melts and outer core anomaly.

[SIT20-P01] Melting relations in the Fe-P system at high pressures

*Yoichi Nakajima[1,2], Haruki Obata[2], Daisuke Kinoshita[2], Shigehiko Tateno[3], Kei Hirose[3,4], Naohisa Hirao[5], Saori I. Kawaguchi[5], Yasuo Ohishi[5] (1.Priority Organization for Innovation and Excellence, Kumamoto University, 2.Department of Phsyics, Kumamoto University,, 3.Earth-Life Science Institue, Tokyo Institute of Technology, 4.Department of Earth and Planertary Science, The University of Tokyo, 5.JASRI)

[SIT20-P02] Elastic property and structure of pyrope glass at high pressure

*Naoki Hisano[1], Tatsuya Sakamaki[1], Tomonori Ohashi[1], Ken-ichi Funakoshi[2], Yuji Higo[3], Yuki Shibazaki[4], Akio Suzuki[1] (1.Department of Earth Science, Graduate School of Science, Tohoku University, 2.Neutron Science & Technology Center, Comprehensive Research Organization for Science and Society (CROSS), 3.Japan Synchrotron Radiation Research Institute, 4.International Center for Young Scientists, National Institute for Materials Science)

[SIT20-P03] The effect of water and redox state on melting at the top of the lower mantle

*Ayano Nakajima[1], Tatsuya Sakamaki[1], Akio Suzuki[1] (1.Tohoku University)

[SIT20-P04] Sound velocity measurements on liquid Fe-P alloy up to 80 GPa

*Daisuke Kinoshita[1], Yoichi Nakajima[1,2], Yasuhiro Kuwayama[2,3], Kei Hirose[3], Daisuke Ishikawa[2,4], Baron Q.R. Alfred[2] (1.Kumamoto University, 2.RIKEN MDL, 3.Tokyo University, 4.JASRI)

[SIT20-P05] High-pressure structural investigations for hydrous sodium silicate melts

*Tomonori Ohashi[1], Tatsuya Sakamaki[1], Ken-ichi Funakoshi[2], Miki Muranushi[1], Chikara Shito[1], Yuki Shibazaki[3], Akio Suzuki[1] (1.Department of Earth Science, Tohoku University, 2.Neutron Science and Technology Center, Comprehensive Research Organization for Science and Society (CROSS), 3.National Institute for Materials Science (NIMS))

[SIT20-P06] Inelastic X-ray scattering measurements of liquid Fe-N alloy under high pressure

*Asaki Iwamoto[1], Yoichi Nakajima[1,2], Daisuke Kinoshita[1], Yasuhiro Kuwayama[2,3], Kei Hirose[3], Daisuke Ishikawa[2,4], Alfred Q.R. Baron[2] (1.Kumamoto University, 2.RIKEN MDL, 3.The University of Tokyo, 4.JASRI)

[SIT20-P07] Formation of highly pure anorthite crust on the low-volatile astral bodies by low-viscous magma ocean

*Tatsuya Sakamaki[1], Yoshio Kono[2] (1.Graduate School of Science, Tohoku University, 2.Geodynamics Research Center, Ehime University)

Melting relations in the Fe-P system at high pressures

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The present-day temperature profile of the Earth's core is key to understanding of the thermal history and dynamics of the core. The temperature in the outer core region is over the melting temperature of the core material and crossovers it at the inner-outer core boundary. Thus, the melting temperature of the core material under relevant high-pressure conditions is crucial to constrain the core temperature. It is well known that the core is composed mainly of Fe, but including 10% lighter elements [1], though the nature of the light elements is still unclear. Phosphorous is also one of the candidates for the core light elements because it is found in iron-meteorites [2] and depleted in the silicate mantle relative to chondrites [3]. In this study, we performed melting experiments on Fe_3P up to 80 GPa by using a laser-heated diamond anvil cell.

The melting relation was determined from in-situ X-ray diffraction measurements at the beamline BL10XU of the SPring-8 synchrotron facility. During heating, we observed a peritectic melting of Fe_3P to liquid + Fe_2P and complete melting up to 60 GPa. The onset and complete melting of the sample were judged from the intensity of diffuse scattering signals from the liquid. This melting phase relation was also confirmed from the chemical analysis on some recovered samples. Above 60 GPa, we observed the change in diffraction pattern of the Fe_3P sample at subsolidus temperature conditions, which might be the decomposition to iron-rich and Fe_2P phases. For this two-phase mixture, we also determined the solidus and liquidus temperatures. In the present experimental pressure conditions, the peritectic (or solidus) and liquidus temperatures of the Fe_3P composition are ~700 K and ~200-300 K lower, respectively, relative to the melting temperature of Fe [4]. These indicate that phosphorous reduces strongly the melting temperature of Fe.

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Keywords: Earth's core, Core light element, Melting relations, High pressure

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Elastic property and structure of pyrope glass at high pressure

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Structural properties of magma are closely correlated to their physical, chemical, and thermal properties. One of approaches for obtaining insights of magmas is an examination of silicate glasses. Aluminum is one of the major elements in the Earth and an important element for controlling the silicate network in melts and glasses because Al^{3+} behaves as an intermediate species in the silicate melts. Aluminum cation can act as either a network former or a modifier, depending on the composition. In the case of a fully-polymerized melt, such as jadeite and albite composition, all TO_4 tetrahedra (where T represents cations, such as Si, Al, etc.) are interconnected via oxygen anions, forming a three-dimensional network structure. Compositional differences are generally considered in terms of variety of alkaline (e.g., Na^{+}) and alkaline-earth (e.g., Mg^{2+}, Ca^{2+}) cations in the melts. These cations are called network modifiers and tend to cut Si-O-Si bonds between a SiO_4 tetrahedron and the adjacent ones. In addition to aluminum cation, other network modifiers also affect the melt behavior. A Mg-aluminosilicate, pyrope ($Mg_3Al_2Si_3O_{12}$) is an important mineral of mantle because of its abundance in the Earth's upper mantle. Change in the slope of melting curve of pyrope around 7-10 GPa has been reported, and pressure-induced Al-coordination change was suggested. Although investigations of structure and elasticity of Mg-aluminosilicate glasses and pyrope-composition glasses have been conducted at ambient pressure, those observations at high pressures are still poor.

Here, we have measured sound velocities of pyrope glass at pressures up to 12.9 GPa using ultrasonic technique at BL04B1 of SPring-8. Longitudinal and transverse wave velocities decreased up to 5.6 GPa, and then the velocities started to increase with pressure. Pressure dependence of elastic moduli and Poisson's ratio of the glass also changed around 7-8 GPa. The structural determination of the glass was conducted based on the energy-dispersive X-ray diffraction method at beamline NE5C of PF-AR in order to understand the mechanism of changes in microscopic physical properties in terms of macroscopic structural evolution. The characteristic shrinkage of the intermediate-range ordering in silicate network was observed around 7 GPa. We could find some correlation between elastic properties and structure. Detailed discussion will be shown in the meeting.

Keywords: silicate glass, elastic wave velocity, X-ray diffraction, structure, ultrasonic measurement

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The effect of water and redox state on melting at the top of the lower mantle

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There are various igneous activities in the Earth. On the surface of the Earth, for example, igneous activities occur in island arcs, mid-ocean ridges, hot spots and petit spots. However, not only on the surface, but also in the interior, melting phenomena are also suggested at the top of the asthenosphere [e.g., Barazangi & Isacks, 1971 *JGR*; Schmerr, 2012 *Science*] and the bottom of the upper mantle [e.g., Bercovici & Karato, 2003 *Nature*; Song *et al.*, 2004 *Nature*]. In this study, we focused on the melting of hydrous peridotite at the top of the lower mantle because seismological observation indicates the low velocity anomaly [Schmandt *et al.*, 2014 *Scienc*e; Liu *et al.*, 2016 *GRL*; Liu *et al.*, 2018 *EPSL*]. The low-velocity region is expected to be caused by mantle melting due to dehydration decomposition of ringwoodite to bridgmanite and ferro-periclase with a downward flow.

Here, we performed melting experiments of peridotite with 2.0 wt. % H_2O at 26 GPa and 1600 ˚C - 2000 ˚C. As a starting material, two peridotite samples were synthesized: one was Fe_2O_3-bearing sample and the other was FeO-bearing. The samples were sealed by gold capsules. Recovered product of reductive sample (= FeO-bearing) from 2000 ˚C and 26 GPa showed a partial melting texture. This indicates that mantle melting can be occurred under this experimental condition. On the other hand, there are no melting texture of recovered sample of Fe_2O_3 system from 2000 ˚C and 26 GPa. In short, the materials constituting the lower mantle melts in the reduced state but not in the oxidized state. It is reported that ferric iron occupies a majority in the redox state at the top of the lower mantle [McCammon, 1997 *Nature* ; Frost *et al.*, 2004 *Nature*]. Thus, it is considered that melting phenomenon may or may not occur due to the regional difference of redox state. At 2000 ˚C, compared to bridgmanite in this study, the composition of melt was SiO_2- and Al_2O_3-poor and MgO- and CaO-rich. Although the FeO component concentrated in the melt, this behavior is closer to the tendency of the anhydrous melting experiments (2400 ˚C or more) [Ito & Takahashi, 1987 *Nature*; Trønnes & Frost, 2002 *EPSL*] than the hydrous system (~1400 ˚C) [Kawamoto, 2004 *PEPI*] because of the small amount of water. We calculated the density and compressibility of the magma based on the obtained melt composition. Comparing with seismological model, this melt is lighter than the lower mantle rock. This implies that a small amount of water (2.0 wt. %) can cause a light melt at the top of lower mantle and form the seismological low velocity zone.

Keywords: dehydration melting, lower mantle, hydrous magma, redox state

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Sound velocity measurements on liquid Fe-P alloy up to 80 GPa

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The Earth’ s liquid outer core is composed mainly of iron, alloying with 5% nickel and 10% lighter elements [1]. The core composition is important to understand the environment and mechanism of the core formation process and the present-day magnetic field. The sound velocity of liquid iron alloys under relevant high-pressure and -temperature conditions in the core is key to constraining the core composition because the direct observations for the core is seismologic wave passing through the core only. Phosphorous is one of the candidates for light elements in the core because it is found in iron-meteorites [2] and depleted in the silicate mantle relative to chondrites [3]. In this study, we determined the P-wave velocity of liquid $Fe_{75}P_{25}$ up to 80 GPa using a laser-heated diamond-anvil cell in combination with an inelastic X-ray scattering (IXS) spectroscopy. We performed IXS measurements at a beamline BL43LXU [4] of the RIKEN SPring-8 Center in Japan. The P-wave velocity of liquid $Fe_{75}P_{25}$ were obtained based on the observed acoustic phonon dispersion. The present results exhibit that the influence of phosphorus on liquid iron sound velocity is almost negligible under the present experimental conditions. On the other hands, the density of liquid Fe can be reduced by phosphorous.

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Keywords: outer core, sound velocity, high pressure

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High-pressure structural investigations for hydrous sodium silicate melts

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The behaviors of high-pressure silicate melts, which is controlled by their physico-chemical properties, are important to understand the magma activity in the deep Earth. Particularly, the H_2O content significantly affects the properties, such as density (e.g., Sakamaki et al., 2006) and viscosity (e.g., Suzuki et al., 2011; Poe et al., 2006). Since such macroscopic properties are known to be largely determined by the microscopic structure, there are considerable interests in revealing how the structure changes with increasing pressure.

Here, structures of hydrous Na_2O-8/3SiO_2 melts with 5 wt% (NS8/3_H5) and with 9 wt% H_2O (NS8/3_H9) were determined under high pressure and temperature by the in-situ X-ray diffraction (XRD). The in-situ XRD study was carried out using a cubic-type multi-anvil apparatus MAX80, which is installed at the AR-NE5C beamline of PF-AR at Tsukuba, Japan. The experimental *P*-*T* conditions were about 1.5–3.0 GPa and 550–970 ˚C, respectively.

The obtained total structure factors, $S(Q)$ of both liquids show that the position of the first sharp diffraction peaks (FSDP) shift to higher-Q with pressure. This positional shift indicates the intermediate-range order structure of present melts become compact. The reduced radial distribution functions, $G(r)$ indicate different pressure evolutions in the average Si-O bond lengths ($r_{Si\text{-}O}$) depending on their water contents. The $r_{Si\text{-}O}$ in the NS8/3_H9 melt shows the monotonic decrease with increasing pressure, however, the $r_{Si\text{-}O}$ of the NS8/3_H5 melt hardly changes after its contraction below 1.6 GPa. The structure of the NS8/3_H9 melt is assumed to be slightly more depolymerized than the NS8/3_H5 melt at ambient pressure (Zotov and Keppler, 1998). This difference might be due to a phenomenon that the number of strongly hydrogen-bonded SiOH groups, which are favored in sodium silicate glasses and melts (Xue and Kanzaki, 2004), increase more significantly during pressure-induced depolymerization in the NS8/3_H9 melt than in the NS8/3_H5 melt. This raises Si(-NBO)/Si(-BO) (NBO: non-bridging oxygen, BO: bridging oxygen) ratio, and hence, the $r_{Si\text{-}O}$ becomes shorter.

Keywords: hydrous silicate melt, effect of water, amorphous structure, high pressure and temperature

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Inelastic X-ray scattering measurements of liquid Fe-N alloy under high pressure

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The Earth’ s liquid outer core is composed mainly of iron, alloying with ~5% nickel and ~10% some light elements [1]. Nitrogen is one of candidates for the light elements. The abundance of nitrogen in the silicate mantle relative to that in primordial meteorites is less than those of similar volatile components such as H_2O, C and Ar, so that large portion of nitrogen in bulk Earth can be stored in the core [2,3]. In order to examine the possibility of nitrogen in the core, it is benefit to compare the sound velocity of liquid Fe-N alloy under high-pressure and -temperature relevant to the core conditions with the seismological observations. In this study, we performed inelastic X-ray scattering (IXS) measurements on liquid Fe-N alloy and determined its longitudinal velocity of the liquid Fe-N alloy under high pressure and temperature.

We carried out high-pressure and -temperature IXS measurements using a laser-heated diamond-anvil cell (LH-DAC) at the beamline BL43LXU of SPring-8 [4]. We used an Fe_4N foil (hereafter called $Fe_{80}N_{20}$) as a starting sample and single crystal Al_2O_3 discs as a thermal insulator. We judged the sample melting based on X-ray diffraction measurements during heating and then measured IXS of the liquid sample. The longitudinal sound wave (P-wave) velocity of liquid $Fe_{80}N_{20}$ was determined from the dispersion relation of the longitudinal acoustic phonon mode of the sample. We obtained the velocity of liquid $Fe_{80}N_{20}$ up to 76 GPa and 2200 K. We found that the P-wave velocity of liquid $Fe_{80}N_{20}$ is slightly faster by c.a. 4% than that of liquid Fe [5]. The P-wave velocity of liquid outer core is faster by 4% than liquid Fe [5]. Therefore, the present results give the upper limit of 5.9 wt.% (20 at.%) for the nitrogen content in the outer core.

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Keywords: Earth's liquid outer core, Light element, P-wave velocity, High pressure

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Formation of highly pure anorthite crust on the low-volatile astral bodies by low-viscous magma ocean

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Anorthite ($CaAl_2Si_2O_8$) is a Ca-endmember of plagioclase, and it is a main component of a crust on the astral bodies, such as Moon and 4 Vesta, Thick anorthite-rich crust has been formed through a process of magma ocean. Here we conduct high-pressure and high-temperature experiments and *in-situ* X-ray analysis to simultaneously assess the viscosity and structure of anorthite magmas under pressures of up to 6.6 GPa. We find contrasting behavior in the viscosity between liquid anorthite and albite ($NaAlSi_3O_8$), which is Na-endmember of plagioclase. The big difference in viscosity between anorthite and albite melts has important implications for planetary differentiation. Na-poor astral bodies (Moon, 4 Vesta, etc.) have been dominated by low-viscous magma ocean and, eventually caused an efficient differentiation between crystal and magma. This process prevented the melt from trapping in the grain boundaries of floating anorthites. This makes the highly pure anorthite crust on the Moon observed by the remote sensing.

Keywords: anorthite melt, viscosity, structure, high pressure, high temperature, lunar magma ocean

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[E] Poster | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_28

[S-IT20] Property and role of liquids inside terrestrial planets

convener:Tatsuya Sakamaki(Department of Earth Science, Tohoku University), Yoichi Nakajima(Kumamoto University, Priority Organization for Innovation and Excellence)

Liquids of silicates and metals inside of terrestrial planets play important role in the physical, chemical, and thermal evolutions of planets. This session aims at understanding the physical and chemical properties of liquids from shallower to deep parts of terrestrial planets, which are strongly related to the long history of those planets from the planetary accretion to the present-day dynamics. In addition, we call for presentations by researchers from various backgrounds of geochemical, experimental, theoretical/computational, and seismic/geodynamical ones, who investigate the physical and chemical properties of liquids and the behaviors and roles inside of terrestrial planets. Relevant topics include, but are not limited to, partial melting and melt extraction, liquid-solid partitioning, high pressure experiments on melts, and seismic detections of mantle melts and outer core anomaly.

[SIT20-P01] Melting relations in the Fe-P system at high pressures

*Yoichi Nakajima[1,2], Haruki Obata[2], Daisuke Kinoshita[2], Shigehiko Tateno[3], Kei Hirose[3,4], Naohisa Hirao[5], Saori I. Kawaguchi[5], Yasuo Ohishi[5] (1.Priority Organization for Innovation and Excellence, Kumamoto University, 2.Department of Phsyics, Kumamoto University,, 3.Earth-Life Science Institue, Tokyo Institute of Technology, 4.Department of Earth and Planertary Science, The University of Tokyo, 5.JASRI)

[SIT20-P02] Elastic property and structure of pyrope glass at high pressure

*Naoki Hisano[1], Tatsuya Sakamaki[1], Tomonori Ohashi[1], Ken-ichi Funakoshi[2], Yuji Higo[3], Yuki Shibazaki[4], Akio Suzuki[1] (1.Department of Earth Science, Graduate School of Science, Tohoku University, 2.Neutron Science & Technology Center, Comprehensive Research Organization for Science and Society (CROSS), 3.Japan Synchrotron Radiation Research Institute, 4.International Center for Young Scientists, National Institute for Materials Science)

[SIT20-P03] The effect of water and redox state on melting at the top of the lower mantle

*Ayano Nakajima[1], Tatsuya Sakamaki[1], Akio Suzuki[1] (1.Tohoku University)

[SIT20-P04] Sound velocity measurements on liquid Fe-P alloy up to 80 GPa

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[SIT20-P05] High-pressure structural investigations for hydrous sodium silicate melts

*Tomonori Ohashi[1], Tatsuya Sakamaki[1], Ken-ichi Funakoshi[2], Miki Muranushi[1], Chikara Shito[1], Yuki Shibazaki[3], Akio Suzuki[1] (1.Department of Earth Science, Tohoku University, 2.Neutron Science and Technology Center, Comprehensive Research Organization for Science and Society (CROSS), 3.National Institute for Materials Science (NIMS))

[SIT20-P06] Inelastic X-ray scattering measurements of liquid Fe-N alloy under high pressure

*Asaki Iwamoto[1], Yoichi Nakajima[1,2], Daisuke Kinoshita[1], Yasuhiro Kuwayama[2,3], Kei Hirose[3], Daisuke Ishikawa[2,4], Alfred Q.R. Baron[2] (1.Kumamoto University, 2.RIKEN MDL, 3.The University of Tokyo, 4.JASRI)

[SIT20-P07] Formation of highly pure anorthite crust on the low-volatile astral bodies by low-viscous magma ocean

*Tatsuya Sakamaki[1], Yoshio Kono[2] (1.Graduate School of Science, Tohoku University, 2.Geodynamics Research Center, Ehime University)

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Keywords: Earth's core, Core light element, Melting relations, High pressure

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Keywords: silicate glass, elastic wave velocity, X-ray diffraction, structure, ultrasonic measurement

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The Earth’ s liquid outer core is composed mainly of iron, alloying with 5% nickel and 10% lighter elements [1]. The core composition is important to understand the environment and mechanism of the core formation process and the present-day magnetic field. The sound velocity of liquid iron alloys under relevant high-pressure and -temperature conditions in the core is key to constraining the core composition because the direct observations for the core is seismologic wave passing through the core only. Phosphorous is one of the candidates for light elements in the core because it is found in iron-meteorites [2] and depleted in the silicate mantle relative to chondrites [3]. In this study, we determined the P-wave velocity of liquid $Fe_{75}P_{25}$ up to 80 GPa using a laser-heated diamond-anvil cell in combination with an inelastic X-ray scattering (IXS) spectroscopy. We performed IXS measurements at a beamline BL43LXU [4] of the RIKEN SPring-8 Center in Japan. The P-wave velocity of liquid $Fe_{75}P_{25}$ were obtained based on the observed acoustic phonon dispersion. The present results exhibit that the influence of phosphorus on liquid iron sound velocity is almost negligible under the present experimental conditions. On the other hands, the density of liquid Fe can be reduced by phosphorous.

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Keywords: outer core, sound velocity, high pressure

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High-pressure structural investigations for hydrous sodium silicate melts

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The behaviors of high-pressure silicate melts, which is controlled by their physico-chemical properties, are important to understand the magma activity in the deep Earth. Particularly, the H_2O content significantly affects the properties, such as density (e.g., Sakamaki et al., 2006) and viscosity (e.g., Suzuki et al., 2011; Poe et al., 2006). Since such macroscopic properties are known to be largely determined by the microscopic structure, there are considerable interests in revealing how the structure changes with increasing pressure.

Here, structures of hydrous Na_2O-8/3SiO_2 melts with 5 wt% (NS8/3_H5) and with 9 wt% H_2O (NS8/3_H9) were determined under high pressure and temperature by the in-situ X-ray diffraction (XRD). The in-situ XRD study was carried out using a cubic-type multi-anvil apparatus MAX80, which is installed at the AR-NE5C beamline of PF-AR at Tsukuba, Japan. The experimental *P*-*T* conditions were about 1.5–3.0 GPa and 550–970 ˚C, respectively.

The obtained total structure factors, $S(Q)$ of both liquids show that the position of the first sharp diffraction peaks (FSDP) shift to higher-Q with pressure. This positional shift indicates the intermediate-range order structure of present melts become compact. The reduced radial distribution functions, $G(r)$ indicate different pressure evolutions in the average Si-O bond lengths ($r_{Si\text{-}O}$) depending on their water contents. The $r_{Si\text{-}O}$ in the NS8/3_H9 melt shows the monotonic decrease with increasing pressure, however, the $r_{Si\text{-}O}$ of the NS8/3_H5 melt hardly changes after its contraction below 1.6 GPa. The structure of the NS8/3_H9 melt is assumed to be slightly more depolymerized than the NS8/3_H5 melt at ambient pressure (Zotov and Keppler, 1998). This difference might be due to a phenomenon that the number of strongly hydrogen-bonded SiOH groups, which are favored in sodium silicate glasses and melts (Xue and Kanzaki, 2004), increase more significantly during pressure-induced depolymerization in the NS8/3_H9 melt than in the NS8/3_H5 melt. This raises Si(-NBO)/Si(-BO) (NBO: non-bridging oxygen, BO: bridging oxygen) ratio, and hence, the $r_{Si\text{-}O}$ becomes shorter.

Keywords: hydrous silicate melt, effect of water, amorphous structure, high pressure and temperature

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Inelastic X-ray scattering measurements of liquid Fe-N alloy under high pressure

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The Earth’ s liquid outer core is composed mainly of iron, alloying with ~5% nickel and ~10% some light elements [1]. Nitrogen is one of candidates for the light elements. The abundance of nitrogen in the silicate mantle relative to that in primordial meteorites is less than those of similar volatile components such as H_2O, C and Ar, so that large portion of nitrogen in bulk Earth can be stored in the core [2,3]. In order to examine the possibility of nitrogen in the core, it is benefit to compare the sound velocity of liquid Fe-N alloy under high-pressure and -temperature relevant to the core conditions with the seismological observations. In this study, we performed inelastic X-ray scattering (IXS) measurements on liquid Fe-N alloy and determined its longitudinal velocity of the liquid Fe-N alloy under high pressure and temperature.

We carried out high-pressure and -temperature IXS measurements using a laser-heated diamond-anvil cell (LH-DAC) at the beamline BL43LXU of SPring-8 [4]. We used an Fe_4N foil (hereafter called $Fe_{80}N_{20}$) as a starting sample and single crystal Al_2O_3 discs as a thermal insulator. We judged the sample melting based on X-ray diffraction measurements during heating and then measured IXS of the liquid sample. The longitudinal sound wave (P-wave) velocity of liquid $Fe_{80}N_{20}$ was determined from the dispersion relation of the longitudinal acoustic phonon mode of the sample. We obtained the velocity of liquid $Fe_{80}N_{20}$ up to 76 GPa and 2200 K. We found that the P-wave velocity of liquid $Fe_{80}N_{20}$ is slightly faster by c.a. 4% than that of liquid Fe [5]. The P-wave velocity of liquid outer core is faster by 4% than liquid Fe [5]. Therefore, the present results give the upper limit of 5.9 wt.% (20 at.%) for the nitrogen content in the outer core.

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Keywords: Earth's liquid outer core, Light element, P-wave velocity, High pressure

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Formation of highly pure anorthite crust on the low-volatile astral bodies by low-viscous magma ocean

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Anorthite ($CaAl_2Si_2O_8$) is a Ca-endmember of plagioclase, and it is a main component of a crust on the astral bodies, such as Moon and 4 Vesta, Thick anorthite-rich crust has been formed through a process of magma ocean. Here we conduct high-pressure and high-temperature experiments and *in-situ* X-ray analysis to simultaneously assess the viscosity and structure of anorthite magmas under pressures of up to 6.6 GPa. We find contrasting behavior in the viscosity between liquid anorthite and albite ($NaAlSi_3O_8$), which is Na-endmember of plagioclase. The big difference in viscosity between anorthite and albite melts has important implications for planetary differentiation. Na-poor astral bodies (Moon, 4 Vesta, etc.) have been dominated by low-viscous magma ocean and, eventually caused an efficient differentiation between crystal and magma. This process prevented the melt from trapping in the grain boundaries of floating anorthites. This makes the highly pure anorthite crust on the Moon observed by the remote sensing.

Keywords: anorthite melt, viscosity, structure, high pressure, high temperature, lunar magma ocean

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[E] Poster | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_7

[S-IT23] Structure and Dynamics of Earth and Planetary Mantles

convener:Takashi Nakagawa(Department of Earth Sciences, The University of Hong Kong), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Dapeng Zhao(Department of Geophysics, Tohoku University)

Interdisciplinary approach can lead to a better understanding of dynamics and evolution of the deep interiors of the Earth and planets. We welcome any submissions of recent results in observational, theoretical and experimental studies on seismology, geomagnetism, mineral physics, dynamics of deep interiors, and any other relevant fields from researchers in many countries. Integration of such results is also welcome. In particular, we encourage any contributions focusing on "plate and mantle dynamics in Earth and terrestrial planets". We also encourage papers stimulating an interdisciplinary collaboration relating to establishment of the Japan-SEDI community.

[SIT23-P01] Interaction between volcanisms inland and the spreading center: example of Galápagos archipelago

*Walid Ben Mansour[1], Guust Nolet[2], Mario Ruiz[3], Juan Carlos Afonso[1] (1.Department of Earth and Planetary Sciences, Macquarie University, Sydney (Australia), 2.Geoazur, Université Cote d'Azur, Sophia Antipolis (France), 3.Instituto Geofisco, Escuela Politecnica Nacional, Quito (Ecuador))

[SIT23-P02] **Effect of iron content on thermal conductivity of olivine with implications for cooling history of rocky planets**

*Youyue Zhang[1], Takashi Yoshino[1], Akira Yoneda[1], Masahiro Osako[2] (1.Institute for Planetary Materials, Okayama University, 2.Division of Physical Sciences, National Museum of Nature and Science)

[SIT23-P03] **The distribution of Cenozoic conglomerates and its sedimentological constraint on the uplift of the South Tianshan, NW China**

*SUN HAITAO[1] (1.China University of Petroluem-Beijing)

[SIT23-P04] **Electrical conductivity of diaspore, δ-AlOOH and ε-FeOOH**

*Ran Wang[1] (1.Institute for Planetary Materials, Okayama University)

[SIT23-P05] Multi-mode surface wave tomography for azimuthal anisotropy in the Australasian upper mantle

*Yuka Nishimura[1], Kazunori Yoshizawa[2] (1. Graduate School of Science, Hokkaido University, 2.Faculty of Science, Hokkaido University)

[SIT23-P06] Mapping multi-mode surface wave phase speeds in North America using mode-branch waveforms decomposed by linear Radon transform

*Hitoshi Matsuzawa[1], Kazunori Yoshizawa[2] (1.Graduate School of Science, Hokkaido University, 2.Faculty of Science, Hokkaido University)

[SIT23-P07] Radial anisotropy in the upper mantle using multi-mode surface waves incorporating the η_k parameter: Application to the Pacific and Australian regions

Shuya Okuyama[1], *Kazunori Yoshizawa[1,2], Hitoshi Kawakatsu[3], Takehi Isse[3] (1.Graduate School of Science, Hokkaido University, 2.Faculty of Science, Hokkaido University, 3.Earthquake Research Institute, University of Tokyo)

[SIT23-P08] Pure to impure and dry to wet olivine rheology based on high temperature dependency of diffusion creep

*Kosuke Yabe[1], Takehiko Hiraga[1] (1.School of Science, The University of Tokyo)

[SIT23-P09] Finite frequency S wave tomography model beneath the Ontong Java Plateau using data recorded by broadband ocean bottom seismographs

*Misaki Horiuchi[3], Hiroko Sugioka[3], Masayuki Obayashi[1], Daisuke Suetsugu[1], Hajime Shiobara[2], Aki Ito[1], Yasushi Ishihara[1], Satoru Tanaka[1], Takehi Isse[2], Takashi Tonegawa[1], Junko Yoshimitsu[1], Takumi Kobayashi[3] (1.Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan, 2.Earthquake Research Institute, The University of Tokyo, Tokyo, Japan, 3.The University of Kobe, Hyogo, Japan)

[SIT23-P10] Shear wave structure of the upper mantle beneath the Ontong Java Plateau

*Takehi Isse[1], Daisuke Suetsugu[2], Hajime Shiobara[1], Hiroko Sugioka[3], Aki Ito[2], Yasushi Ishihara[2], Satoru Tanaka[2], Masayuki Obayashi[2], Takashi Tonegawa[2], Junko Yoshimitsu[2], Takumi Kobayashi[3], Kazunori Yoshizawa[4] (1.Earthquake Research Institute University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Kobe University, 4.Faculty of Science, Hokkaido University)

[SIT23-P11] Effect of impurity on post-post-perovskite transition of $MgSiO_3$ by first principles

*Koichiro Umemoto[1] (1.Earth-Life Science Institute, Tokyo Institute of Technology)

[SIT23-P12] Unsusual high-Ti corundum recovered from the Horoman peridotites, Hokkaido, Japan

*oosawa takumi[1], Shinji Yamamoto[1] (1.yokohama national university)

[SIT23-P13] Deformation experiments on akimotoite

*Longli Guan[1], Daisuke Yamazaki[1], Noriyoshi Tsujino[1] (1.Institute for Planetary Materials, Okayama University, Misasa, Japan)

[SIT23-P14] Fate of water in subducted hydrous sediments deduced from stability fields of FeOOH and AlOOH up to 20 GPa

*Takashi Yoshino[1], Edward Baker[2], Kyle Duffey[3] (1.Institute for Planetary Materials, Okayama University, 2.Department of Earth Sciences, University of Oxford, 3.Department of Geosciences, Princeton University)

Interaction between volcanisms inland and the spreading center: example of Galápagos archipelago

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The Galápagos archipelago, located west of Ecuador, is a good example where a mantle plume interacts with a spreading center and modifies physical and chemical properties of the oceanic lithosphere. The Galápagos Spreading Center (GSC) and the Galápagos hotspot interact over more than 1,000 km with unusual features for a hot spot region (large number of historical active volcanoes, large range of lavas composition, alignment of volcanic centers and seamounts). To bring new information on the physical and chemical properties of this region, we are constructing a new P-wave velocity model of this region by combining data from 10 seismic broadband stations and from 9 MERMAIDS (Mobile Earthquake Recorder in Marine Areas by Independent Divers) deployed in this region between 2014 and 2016. We focus on Pn head waves to better constraint the Moho depth in this region and image the interaction between the hot spot and the GSC. We selected150 seismic events between May 2014 and September 2016, with epicentral distance between $3^{o}$and 35^{o} and picked more than 2,500 Pn phases that we will invert in a probabilistic tomography inversion in a second step. In this presentation, we will show examples and statistics of Pn data. We will discuss the benefits of developing a multi-observable thermochemical tomography in this region to better image the intricate interaction of a hot spot with the overlying oceanic lithosphere and evaluate current physio-chemical evolutionary models.

Keywords: Pn tomography, mantle plume, thermochemical structure

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Effect of iron content on thermal conductivity of olivine with implications for cooling history of rocky planets

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Knowledge of thermal transport properties of mantle materials is essential for understanding the thermal state and dynamics of the Earth and planetary interiors. Previous studies have suggested that temperature and pressure dependences of thermal conductivity can affect mantle convection and plate tectonics involving subduction dynamics. Olivine is the most abundant mineral in the Earth's upper mantle and chemical composition of olivine in the Earth's upper mantle is characterized by high forsterite content around Fo_{90}. For other terrestrial planets, Mercury is believed to have a FeO-poor mantle along with end member silicates, whereas olivine in the Martian mantle would be more Fe-rich, speculated to be Fo_{67}. Recent studies suggested that surface of some asteroids is dominated by olivine of composition from Fo_{49} to Fo_{70}. Hence, the effect of Fe content in olivine on thermal conductivity could be significant for understanding the thermal structure and cooling history of these terrestrial planets and asteroids.

In this study, thermal conductivity and diffusivity of olivine were determined simultaneously by combining multi-anvil high pressure experimental technique and pulse heating method. Thermal properties of olivine with six different Fe contents (Fo, Fo_{90}, Fo_{70}, Fo_{50}, Fo_{31}, Fo_{0}) were measured under the Earth's upper mantle condition in a 5000-ton Kawai type multi-anvil press. The minimum λ was found to be at composition near Fo_{31}; the absolute λ value of Fo_{31} is about 65% lower than that of Fo. Small amounts of minor elements can strongly reduce the thermal conductivity at low temperature; λ value of Fo90 is about 50% of Fo at room temperature. As temperature increases, the difference in λ among olivine samples with various Fe contents tends to become smaller. Thermal conductivities of polycrystalline olivine have smaller absolute values and weak pressure and temperature dependences, compared with those of natural single crystal olivine determined by previous studies. Heat capacity of olivine calculated from λ and κ is independent of pressure and is controlled by nearly constant thermal expansion coefficient of Fo_{70} and Fo_{50} with increasing temperature. Smaller λ of olivine aggregate with high Fe content would produce thicker crust in the Fe-rich Mars, while heat in the Fe-poor Mercury can escape faster than the other terrestrial planets. Olivine-dominant asteroids with high Fe concentration could have longer cooling history and lower thermal inertia on the surface.

Keywords: Thermal conductivity, Olivine, Heat capacity, High pressure, Mantle

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The distribution of Cenozoic conglomerates and its sedimentological constraint on the uplift of the South Tianshan, NW China

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The Cenozoic alluvial fan deposits in the Kuqa Depression of Tarim Basin, likely in response to a tectonic event, can provide critical evidence for constraining the timing of the South Tianshan uplift and reconstructing the paleotectonic evolution of the Central Asian Orogenic Belt. The sedimentological analysis shows that the conglomerates were deposited in alluvial fan environment. The initial uplift stage was started from the Jidike Formation at ~23Ma, resulting only small but angular gravels. Then the rapid uplift was since 15.97 Ma leading to the deposition of Kangcun conglomerate layers. And the next rapid and intensely uplift was started at ~4 Ma of the deposition of Kuqa Formation, according to ~2000m thick alluvial fan conglomerates. After a short quiescence, the most remarkable uplift of South Tianshan regenerated and caused the most extensive alluvial fan conglomerates of Xiyu Formation since 2.58 Ma and continuing to the present.

Keywords: Cenozoic, Central Asian Orogenic Belt, Conglomerate

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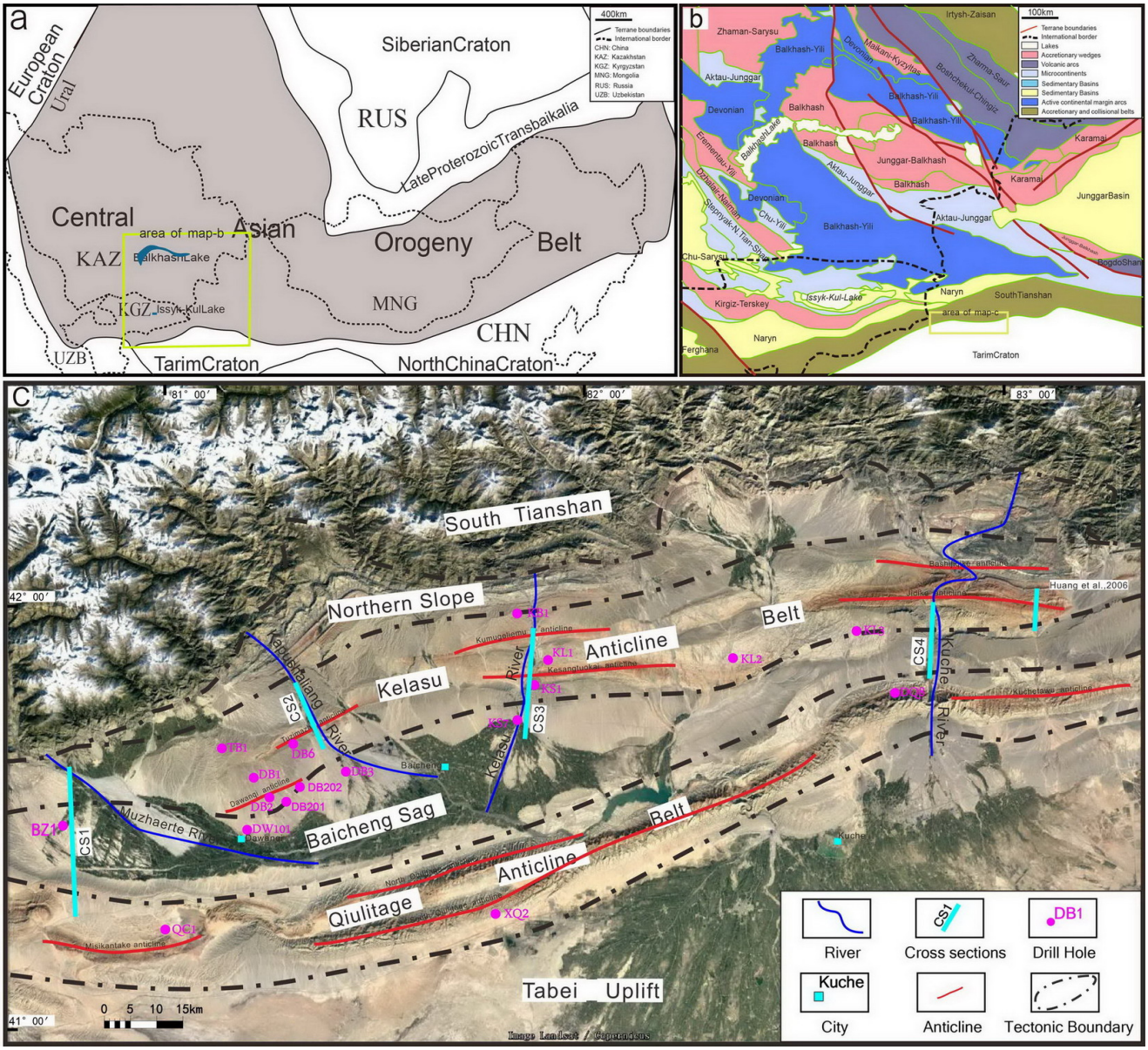

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Electrical conductivity of diaspore, δ-AlOOH and ε-FeOOH

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FeOOH and AlOOH are dominant hydrous phases in sedimentary rocks deposited in the sea or lake basins which were considered to be possibly related to the deep water cycle by slab subduction. Therefore, understanding of the electrical conductivity behaviors of these phases are essential to explore the nature and dynamic process of the Earth's interior. In this study, electrical conductivity of diaspore (α-AlOOH), δ-AlOOH and ε-FeOOH was measured by impedance spectroscopy with a frequency range from 10^{-1} to 10^{6} Hz at pressures up to 15, 20 and 12 GPa and temperatures of 1200, 1200 and 1000 K well below the dehydration temperatures of these phases under the relevant pressures. For diaspore at 8, 10, and 12 GPa, the relationship between electrical conductivity and reciprocal temperature could be well fitted by the Arrhenius formula: $\sigma = \sigma_0 \exp[-(\Delta E + P\Delta V)/kT]$ and shows the pre-exponential factor (σ_0), activation energy (ΔE) and activation volume (ΔV) of 55.94 ±1.16 S/m, 0.547 ±0.016 eV and 1.683 ±0.123 cm^3/mol, respectively. However, data of diaspore obtained below 6 GPa could not be fitted by the Arrhenius formula, which was thought to be due to the remnant of free water in the sample caused by heating to insufficient temperature to proceed dehydration of interstitial water. Thus, it is quite difficult to measure the electrical conductivity of diaspore at low pressures. The electrical conductivity of diaspore increased with pressures ranging from 8 to 12 GPa by half order of magnitude and then the conductivity change with pressures from 12 to 15 GPa became negligibly small. The dominant conduction mechanism of diaspore is regarded as proton conduction. δ-AlOOH and ε-FeOOH show one and two orders of magnitude higher electrical conductivity than diaspore. Due to isostructural $CaCl_2$-type hydroxide structure, δ-AlOOH and ε-FeOOH display the nearly identical activation enthalpy (0.384 ±0.007 eV, 0.330 ±0.048 eV) which is relatively lower than that of diaspore.

Keywords: Electrical conductivity, Diaspore, δ-AlOOH, ε-FeOOH

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Multi-mode surface wave tomography for azimuthal anisotropy in the Australasian upper mantle

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Azimuthal anisotropy in the upper mantle derived from seismic surface waves provides us with the information of mantle dynamics, such as the present-day mantle flow and the remnant of past deformation in the lithosphere and asthenosphere.The Australian plate is currently the fastest-moving tectonic plate including a large continent, encompassed by the intensive seismicity, particularly in its north (Indonesia) and east (Tonga-Kermadec to New Zealand). Thus, the entire continent can be covered by dense ray paths utilizing broad-band seismic stations deployed throughout the continent. This unique tectonic setting of Australian plate allows us to reconstruct high-resolution tomography models in the Australian region (e.g., Fishwick et al., 2008, Tectonics; Yoshizawa, 2014, PEPI).

In this study, we construct new phase speed maps in and around the Australian continent incorporating azimuthal anisotropy for both multi-mode Love and Rayleigh waves using the method developed by Yoshizawa & Kennett (2004, JGR). We employ the data base of path-specific multi-mode phase speeds for the fundamental mode and up to the fourth-higher modes by Yoshizawa (2014, PEPI), which has been measured by using the non-linear waveform fitting method (Yoshizawa & Ekstrom, 2010, GJI). We have performed checkerboard resolution tests as well as jackknife resampling tests, which suggest that our current phase speed data set can provide us with the robust estimation of azimuthally anisotropic phase speed maps in the Australasian region.

The multi-mode phase speed models indicate that the fastest directions of azimuthal anisotropy estimated from the different modes are consistent each other as far as they have the maximum sensitivity at the common depth. Comparisons between the direction of absolute plate motion (HS2-NUVEL-1) by Gripp & Gordon (1990, GRL) and the fastest direction of azimuthal anisotropy suggests that they agree well particularly at around the depth of 100km under the ocean area (Coral and Taman Seas) off the east-coast of the Australian continent and 300km under the continental area of Australia. These results are likely to reflect the differences in the depth of asthenosphere where the effects of the lattice preferred orientation of mantle materials due to the present-day mantle flow can be more significant.

Keywords: Azimuthal anisotropy, Surface wave tomography, Australia

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Mapping multi-mode surface wave phase speeds in North America using mode-branch waveforms decomposed by linear Radon transform

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The use of higher-mode surface waves is inevitable for further enhancement of vertical resolution of tomography model since they are much more sensitive to the deep structure of the Earth’ s upper mantle than the fundamental modes. However, measuring the multi-mode phase speeds is not a straightforward issue since wavetrains of different modes overlap each other in a seismogram.

We have developed the two-step array-based method for higher-mode analysis, which consists of (1) multi-mode phase speed measurements based of a classical *f-k* analysis using a long-range linear array with several-thousand kilometers (e.g., Nolet, 1975, GRL) and (2) modal waveform decomposition for the centroid location of the linear array using the linear Radon transform (e.g. Luo *et al*., 2015, GJI).

We have previously applied the method to a large data set of seismograms observed at Transportable Array stations of USArray and employed the average phase speeds of linear array to map phase speed distributions in North America (Matsuzawa and Yoshizawa, SSJ Fall Meeting 2018; AGU Fall Meeting 2018). We could obtain phase speed maps of the fundamental-mode and the first four higher-mode surface waves. Although the large-scale anomalies (i.e., fast phase speeds in cratons in the stable eastern U.S., slow phase speeds in the tectonically-active western U.S.) can be identified, the lateral resolution of the phase speed maps were insufficient compared to inter-station/array based tomography models. This suggests that the small-scale tectonic features have been blurred and averaged out due to the direct use of long linear array (2000–4000 km) with relatively large measurement errors.

In this study, we apply the inter-station dispersion analysis with nonlinear waveform fitting (Hamada and Yoshizawa, 2015, GJI) to the decomposed modal waveforms of the fundamental-mode surface waves derived from method using the centroids of the linear array as imaginary stations.The lateral resolution of resultant phase speed maps has been improved up to about 2.0 degrees owing to the relatively shorter inter-station (inter-centroid) distances used in the inversions.We can find typical small-scale tectonic features in the inland region of eastern and central US. Average phase speeds along each short ray path (several-hundred kilometers) have been measured stably without interference by overtones, which is likely to be of help in improving the accuracy of the resultant tomography maps.

The decomposed modal waveforms of the higher modes as well as the fundamental mode can be applied to the secondary dispersion analyses such as the inter-station dispersion measurements as done in this study and/or a 2-D beamforming analysis, which can be expected to enhance both the lateral and vertical resolutions of surface wave tomography models.

Keywords: Surface wave, Higher mode, Array-based analysis, Tomography, North America

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Radial anisotropy in the upper mantle using multi-mode surface waves incorporating the η_κ parameter: Application to the Pacific and Australian regions

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Radial anisotropy can be described by five elastic parameters; four parameters related to seismic wave speeds (β_v, β_h, α_h, α_v) and an additional fifth anisotropic parameter (η). One of the anisotropic parameters, η, was originally defined by Anderson (1961), but its physical proprieties have been rather unclear compared with other four parameters related to elastic velocity.

The re-defined fifth anisotropic parameter η_κ by Kawakatsu et al. (2015) makes it easier to understand its physical proprieties compared with conventional η. The introduction of η_κ affects the shape of sensitivity kernels of Rayleigh wave phase speeds with respect to η_κ, PH-wave speeds α_h and PV-wave speeds α_v (Kawakatsu, 2016b). Since the sensitivity of Rayleigh wave phase speeds to η_κ becomes greater than that to η, we can expect a possibility of resolving the η_κ parameter. However, since the inverse correlation between the sensitivity kernels of SV-wave speed β_v and η_κ becomes rather stronger, the trade-off between β_v and may easily occur. Therefore, the independent determination of η_κ parameter from the inversions of surface-wave dispersion curves is not a straightforward issue.

In this study, incorporating η_κ, we performed inversions for five elastic parameters in the upper mantle, employing a classical iterativenonlinear least-squares inversion method (Tarantola and Valette, 1982). We used multi-mode dispersion data sets of surface waves in the Australian region (Yoshizawa, 2014, PEPI) and Pacific (Isse et al., 2019, EPSL) to reconstruct 3-D radially anisotropic model. In these inversions, we used isotropic PREM as a starting model to avoid the influence of reference anisotropy model.

The retrieved spatial distribution of the η_κ parameter can be mostly explained by trade-offs with SV wave speed β_v at many locations in Australia and Pacific. Still, we can find structural features in our 3-D β_v and η_κ models, particularly in some major structural boundaries such as ridges and the Tasman Line in eastern Australia, which cannot simply be attributed to the trade-off between β_v and η_κ, indicating possible intrinsic character of η_κ in the upper mantle.

Keywords: radial anisotropy, surface waves, inversion

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Pure to impure and dry to wet olivine rheology based on high temperature dependency of diffusion creep

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There has been a large discrepancy in creep properties of olivine aggregates in dry diffusion creep regime between Minnesota group (Hirth and Kohlstedt, 1995) and ANU group (Faul and Jackson, 2007). Our recent deformation experiments on undoped and doped olivine aggregate synthesized by a new method different from previous studies demonstrate (i) the activation energy of grain boundary diffusion creep of undoped olivine is 465 kJ/mol, (ii) the creep rate is enhanced by doping of Ca and Al above ~1200 C with very high temperature sensitivity well represented by activation energy of ~700 kJ/mol, and (iii) presence of melt phase had little contribution to the change in the creep strength. Such observations are consistent with Yamauchi and Takei (2016) which attributed the observation to pre-melting at near solidus.

In this study, we compile all rheological data of olivine diffusion creep based on solidus which changes with the chemical compositions and amount of water. The solidi of dry samples are estimated from experiments and/or phase diagrams. The solidi of wet samples are calculated by cryoscopic approach following Hirshmann et al. (2009). We demonstrate that not only dry but also wet data are well explained by the operation of grain boundary diffusion creep with activation energy of 465 kJ/mol at <~0.93 × solidus and 700 kJ/mol at >~0.93 ×solidus. The controversy on the effect of water on grain boundary diffusion by Mei and Kohlstedt (2000) and Fei et al. (2016) is explained by the experimental temperatures with respect to the solidus of their systems. The viscosity depth profile in the upper mantle based on our new diffusion creep model will be presented.

Keywords: mantle rheology, olivine aggregates, diffusion creep

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Finite frequency S wave tomography model beneath the Ontong Java Plateau using data recorded by broadband ocean bottom seismographs

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We determined three-dimensional S wave model beneath the Ontong Java Plateau (OJP) by finite frequency tomography using data recorded by broadband seismographs deployed at ocean bottom covered the OJP and at neighbor islands (Suetsugu *et al.*, 2018). Our dataset contains absolute and period-depended differential travel time data. The former consists of ~1,100,000 direct S-wave onset times reported by International Seismological Centre (ISC) and ~400 direct S-wave onset times picked up on broadband waveform records around the OJP and the latter is composed of ~3,000 differential traveltimes between two different stations around the OJP measured by waveform cross correlation at 7 different passband of which center periods varies from 5.3 sec to 42 sec. We used adaptive stacking method (Rawlinson and Kennett, 2004) to measure absolute travel time data near the OJP. These data were inverted based on the infinite frequency travel time tomography method for the absolute travel time data (Inoue *et al.*, 1990; Fukao *et al.*, 1992; Obayashi *et al.*, 2013) and the finite frequency travel time method for the relative travel time data (Dahlen *et al.*, 2000; Obayashi *et al.*, 2013). We obtained a well resolved S wave velocity model beneath the OJP. It shows significant high velocity anomalies in the mantle transition zone, which are considered as stagnant Pacific slabs related to the trench retreating as well as seafloor spreading in the Santa Cruz Basin and Melanesia Basin during the Eocene and Oligocene. It also reveals that S wave velocity just below the OJP is a little higher than the surrounding strong slow anomalies in the mantle shallower than 200 km. We will discuss these remarkable features beneath the OJP in comparison with P wave tomographic model (Obayashi *et al.*, 2018) in this presentation.

Keywords: finite frequency tomography, S wave velocity structure

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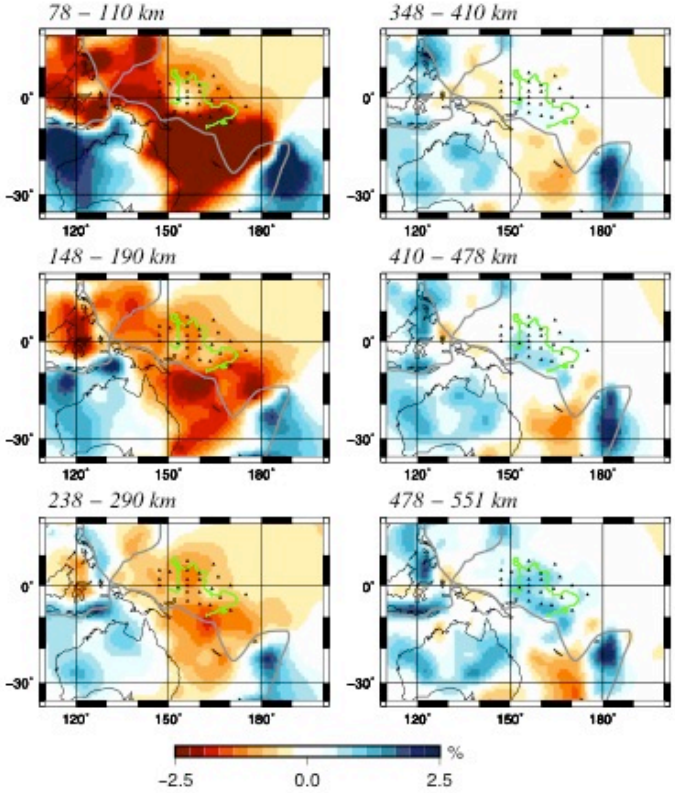
(a)



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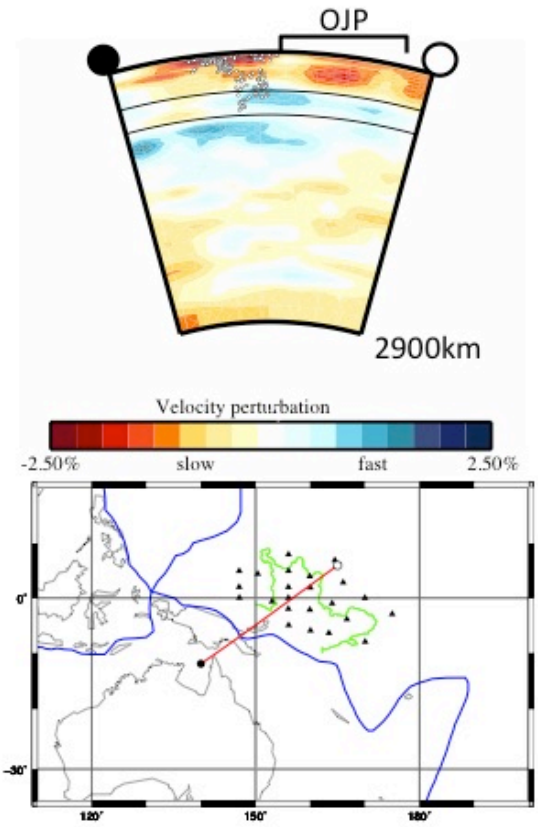

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Shear wave structure of the upper mantle beneath the Ontong Java Plateau

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Ontong Java Plateau (OJP) is the vastest Large Igneous Provinces (LIPs) in the oceanic region of the Earth. The OJP was emplaced at 122 and 90 Ma by massive volcanism, but the origin of this volcanism is still under discussion.
Richardson et al. (2000) obtained a large low-velocity root of the OJP extending as deep as 300km, though its existence and cause are still in debating.
One reason for poor understanding of the OJP is the insufficient information about the crust and mantle structure beneath the OJP because of the lack of long-term seafloor observation. Between 2014 and 2017, we conducted the first seismological and electromagnetic observations on the seafloor and islands in the OJP, named "OJP array", to clarify the origin of the OJP.
Using the broadband data from the OJP array as well as those from stations on land and seafloor in the western Pacific Ocean, we constructed three-dimensional shear wave speed structure beneath the OJP by surface wave tomography. using phase speed dispersions of Love and Rayleigh waves up to the 4th higher modes. Checkerboard resolution tests suggests that the spatial resolution of the obtained model is ~300km, which is higher than previous studies.

Obtained shear wave speed structure down to the depth of 300 km shows the following new features:
(1) In the center of the OJP at depths between 70–150 km, about 2% fast anomalies exists;
(2) No strong slow anomaly is found beneath the OJP at depths down to 300 km;
(3) Beneath the Caroline Islands, in the north of the OJP, 2 % slow anomalies exist, which may be associated with the Caroline hotspot activity.

These newly found features suggest that further investigation to reveal the origin of the OJP is necessary.

Keywords: upper mantle structure, Ontong Java, surface wave tomography, BBOBS

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Effect of impurity on post-post-perovskite transition of $MgSiO_3$ by first principles

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Several computational studies have predicted post-post-perovskite transitions in MgSiO3 at ultrahigh pressures and temperatures which can occur at deep interiors of super-Earths: $MgSiO_3$ --> Mg_2SiO_4+ $MgSi_2O_5$ --> Mg_2SiO_4+ SiO_2 --> MgO + SiO_2) and recombination (MgO + $MgSiO_3$ --> Mg_2SiO_4 or SiO_2 + $MgSiO_3$ --> $MgSi_2O_5$) [1-5]. As demonstrated in a very recent numerical simulation, these transitions are crucially important in modeling interiors of super-Earths up to 20 times Earth’ s mass [6]. However, in the previous studies, these post-post-perovskite transitions were considered only for pure Mg-Si-O. In actual super-Earths, impurities, Fe, Al, or so forth, should exist. Here we will investigate effects of impurities on post-post-perovskite transitions: transition pressures, local atomic structures, and equation of states.

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Keywords: super-Earth, post-post-perovskite transition, first principles

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Unsusual high-Ti corundum recovered from the Horoman peridotites, Hokkaido, Japan

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Oceanic and continental crust are recycled into the mantle due to subduction of oceanic plate in the mantle, and the crustal materials are thought to be mixed in the mantle through mantle convection (W.Xu et al., 2008). However, the mode and process of crustal mixing in peridotites are unknown, and constraints using recycled crust minerals are needed for elucidating the mantle-crust circulations. Horoman peridotites, located in the Hidaka Mountains of Hokkaido, is known as a fresh peridotite that is less serpentinized. By the metasomatism of the melt-mantle reaction, the harzburgite-lherzolite shows a remarkable stratigraphic structure. Recently, the occurrence of crustal minerals has been reported by Li et al., (2017) from the Horoman peridotites, such as zircon, rutile, diamond with a low carbon isotopic ratio, suggesting that these crustal minerals in the Horoman peridotites have recycled origin due to the past subduction and mixing in the mantle. However, the origin of crustal minerals in the Horoman peridotitare unclear, and few recovered cases. To better understand the origin of crustal minerals in the Horoman peridotites. we improve the mineral separation techniques and recovered unusual Ti-rich corundum from the Horoman peridotite. describe the separated minerals in details.

In this study, peridotite samples collected from the quarry of Toho Olivine Industry Co., Ltd., were employed for the heavy mineral separations. Each peridotite samples, 764 kg of harzburgite and 954 kg of lherzolite, were cut to a plate shape and transported to the Yokohama National University. Using a jaw crusher and a continuous crusher, it was crushed to 0,1 mm in size and then subjected to sieving, gravity, and magnetic separations, and finally hand picking the remaining minerals, which embedded in epoxy resin and polished. Six zircons, one rutile (TiO_2) were recovered from within the lherzolite. On the other hand, grains recovered from nonmagnetic fraction harzburgitewere embedded for mineral exploration using EPMA , and as a result, twelve corundum (Al_2O_3) grains were discovered. Inclusions and attached minerals coexisted in corundum were observed under the stereoscopic microscope. SEM-EDS analysis of six corundum grains confirmed that inclusions and attatched phase consisting of (1) Si-Al-K rich silicate, (2)Ti-Zr oxide,aand (3) Si-Ti alloy.

Morishita et al., (1998; 2000) previously reported the corundum xenocryst containing a trace amount of Cr from the gabbro boulder in the Ponsanushibetsu river in Samani town. This corundum is interpreted as a metamorphic product of gabbro protolith or xenocrust from the Hidaka crust. The characteristics of corundum obtained in this study is (1) almost no Cr, (2) unusual high-Ti content (maximum 2.3 wt% of TiO_2), (3) unique inclusions such as Ti-Zr oxide and Si-Ti alloys. Therefore, it is thought that a corundum recovered from the Horoman peridotite have different origin from that of Morishita et al. (1998; 2000). In another case, corundum with high TiO_2 concentration and specific inclusion (Ti-Zr oxide, Ti-Si alloy) has been reported from xenocrysts related from alkaline basalts of Israel Mt.Carmel (Griffine et al., 2016; 2018). Origin of Mt. Carmel corundum is still unclear, but tentatively proposed to be crystallized from mafic to ultramafic melt near the crust-mantle boundary under the highly reducing conditions (Griffine et al., 2018) The discovery of unusual high-Ti corundum from the Horoman peridotites will shed light on significant petrological issue on peridotite studies.

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Keywords: mantle peridotite , recycle, corundum, Titanium

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Deformation experiments on akimotoite

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The ilmenite structure of $MgSiO_3$, known as akimotoite, is inferred to occur in cold subducting slabs in the bottom of Earth's mantle transition zone and the uppermost lower mantle along a low-temperature geotherm (Akaogi et al., 2002). Akimotoite is thought to be the most anisotropic mineral in the Earth's mantle transition zone (Zhang et al., 2005; Weidner & Ito,1985). The elastic anisotropy caused by the lattice preferred orientation of akimotoite due to slab-induced deformation may be used plausibly to interpret the significant seismic anisotropy observed in mid-mantle (depths 410-670km) (Nowacki et ali.,2015; Foley & Long, 2011). However, previous studies did not determine the slip plane or the dominant slip system precisely (Shiraishi et al., 2008). In this study, therefore, we conducted deformation experiment on akimotoite aggregates to investigate precise and detailed microstructures. For the preparation of starting material of akimotoite aggregates for deformation experiment, high pressure experiments using $MgSiO_3$ glass as starting material have been performed at 20-22GPa and 1400 ℃, in the Kawai-type multi anvil apparatus. The recovered samples were investigated by X-ray diffraction, electron probe microanalysis and scanning electron microscopy to identify phase, measure chemical composition and observe microstructure, respectively, showing that samples were well-sintered and no-crack akimotoite aggregates with grain size of 2-8 μm. These akimotoite aggregates were suitable as a starting material for deformation experiments. We subsequently conducted pure shear deformation experiment on such akimotoite aggregates at ~21 GPa and 1200 ˚C by using high pressure deformation apparatus, so called D-111 type apparatus, installed at Institute for Planetary Materials, Okayama University. The relationship between displacement and load of D-rams may suggest the mechanism change from elastic to plastic deformation with the progress of deformation. As a result, we observed the plastic deformation on the recovered sample and the strain and average strain rate were estimated to be ~0.12 and ~1.6×10^{-5} s^{-1}, respectively. It is considered that the strain of ~0.12 is sufficient to form the lattice preferred orientation which can be analyzed by electron backscattered diffraction technique.

Keywords: akimotoite, lattice preferred orientation, deformation at high pressure, anisotropy , mantle

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Fate of water in subducted hydrous sediments deduced from stability fields of FeOOH and AlOOH up to 20 GPa

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1. Institute for Planetary Materials, Okayama University, 2. Department of Earth Sciences, University of Oxford, 3. Department of Geosciences, Princeton University

Fe- and Al-hydroxides (FeOOH and AlOOH) in sedimentary rocks form the top part of the subducted oceanic lithosphere and are known to be stable along a normal geotherm in the lower mantle. Banded Iron Formations (BIFs) and bauxite ore deposits formed in the Earth’s oceans can transport significant amount of water into the Earth’s deep interior by subduction of FeOOH and AlOOH and may occasionally serve water to the core. However, stabilities of these hydrous phases have not been well constrained in upper mantle conditions. We determined dehydration curves for FeOOH and AlOOH in upper mantle and mantle transition zone conditions (5–20 GPa, 673–1573K)by quench and *in situ*X-ray diffraction to constrain their capability of water transport to the deep mantle. Dehydration temperatures of these minerals increase with increasing pressure. Comparison between our results and geothermal gradients of subducting slab surfaces demonstrates dehydration of FeOOH in early subduction stage (around 2 GPa). In most cases, diaspore (AlOOH) also dehydrates in early subduction. Despite the implications of the stability of these phases at high pressure, our results show that the sediments located at the slab surface are unlikely candidates for transporting water to the deep mantle.

Keywords: water, sediment, dehydration, hydrous minerals, subduction

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[E] Poster | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_29

[S-IT23] Structure and Dynamics of Earth and Planetary Mantles

convener:Takashi Nakagawa(Department of Earth Sciences, The University of Hong Kong), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Dapeng Zhao(Department of Geophysics, Tohoku University)

Interdisciplinary approach can lead to a better understanding of dynamics and evolution of the deep interiors of the Earth and planets. We welcome any submissions of recent results in observational, theoretical and experimental studies on seismology, geomagnetism, mineral physics, dynamics of deep interiors, and any other relevant fields from researchers in many countries. Integration of such results is also welcome. In particular, we encourage any contributions focusing on "plate and mantle dynamics in Earth and terrestrial planets". We also encourage papers stimulating an interdisciplinary collaboration relating to establishment of the Japan-SEDI community.

[SIT23-P01] Interaction between volcanisms inland and the spreading center: example of Galápagos archipelago

*Walid Ben Mansour[1], Guust Nolet[2], Mario Ruiz[3], Juan Carlos Afonso[1] (1.Department of Earth and Planetary Sciences, Macquarie University, Sydney (Australia), 2.Geoazur, Université Cote d'Azur, Sophia Antipolis (France), 3.Instituto Geofisco, Escuela Politecnica Nacional, Quito (Ecuador))

[SIT23-P02] **Effect of iron content on thermal conductivity of olivine with implications for cooling history of rocky planets**

*Youyue Zhang[1], Takashi Yoshino[1], Akira Yoneda[1], Masahiro Osako[2] (1.Institute for Planetary Materials, Okayama University, 2.Division of Physical Sciences, National Museum of Nature and Science)

[SIT23-P03] **The distribution of Cenozoic conglomerates and its sedimentological constraint on the uplift of the South Tianshan, NW China**

*SUN HAITAO[1] (1.China University of Petroluem-Beijing)

[SIT23-P04] **Electrical conductivity of diaspore, δ-AlOOH and ε-FeOOH**

*Ran Wang[1] (1.Institute for Planetary Materials, Okayama University)

[SIT23-P05] Multi-mode surface wave tomography for azimuthal anisotropy in the Australasian upper mantle

*Yuka Nishimura[1], Kazunori Yoshizawa[2] (1. Graduate School of Science, Hokkaido University, 2.Faculty of Science, Hokkaido University)

[SIT23-P06] Mapping multi-mode surface wave phase speeds in North America using mode-branch waveforms decomposed by linear Radon transform

*Hitoshi Matsuzawa[1], Kazunori Yoshizawa[2] (1.Graduate School of Science, Hokkaido University, 2.Faculty of Science, Hokkaido University)

[SIT23-P07] Radial anisotropy in the upper mantle using multi-mode surface waves incorporating the η_k parameter: Application to the Pacific and Australian regions

Shuya Okuyama[1], *Kazunori Yoshizawa[1,2], Hitoshi Kawakatsu[3], Takehi Isse[3] (1.Graduate School of Science, Hokkaido University, 2.Faculty of Science, Hokkaido University, 3.Earthquake Research Institute, University of Tokyo)

[SIT23-P08] Pure to impure and dry to wet olivine rheology based on high temperature dependency of diffusion creep

*Kosuke Yabe[1], Takehiko Hiraga[1] (1.School of Science, The University of Tokyo)

[SIT23-P09] Finite frequency S wave tomography model beneath the Ontong Java Plateau using data recorded by broadband ocean bottom seismographs

*Misaki Horiuchi[3], Hiroko Sugioka[3], Masayuki Obayashi[1], Daisuke Suetsugu[1], Hajime Shiobara[2], Aki Ito[1], Yasushi Ishihara[1], Satoru Tanaka[1], Takehi Isse[2], Takashi Tonegawa[1], Junko Yoshimitsu[1], Takumi Kobayashi[3] (1.Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan, 2.Earthquake Research Institute, The University of Tokyo, Tokyo, Japan, 3.The University of Kobe, Hyogo, Japan)

[SIT23-P10] Shear wave structure of the upper mantle beneath the Ontong Java Plateau

*Takehi Isse[1], Daisuke Suetsugu[2], Hajime Shiobara[1], Hiroko Sugioka[3], Aki Ito[2], Yasushi Ishihara[2], Satoru Tanaka[2], Masayuki Obayashi[2], Takashi Tonegawa[2], Junko Yoshimitsu[2], Takumi Kobayashi[3], Kazunori Yoshizawa[4] (1.Earthquake Research Institute University of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Kobe University, 4.Faculty of Science, Hokkaido University)

[SIT23-P11] Effect of impurity on post-post-perovskite transition of $MgSiO_3$ by first principles

*Koichiro Umemoto[1] (1.Earth-Life Science Institute, Tokyo Institute of Technology)

[SIT23-P12] Unsusual high-Ti corundum recovered from the Horoman peridotites, Hokkaido, Japan

*oosawa takumi[1], Shinji Yamamoto[1] (1.yokohama national university)

[SIT23-P13] Deformation experiments on akimotoite

*Longli Guan[1], Daisuke Yamazaki[1], Noriyoshi Tsujino[1] (1.Institute for Planetary Materials, Okayama University, Misasa, Japan)

[SIT23-P14] Fate of water in subducted hydrous sediments deduced from stability fields of FeOOH and AlOOH up to 20 GPa

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Interaction between volcanisms inland and the spreading center: example of Galápagos archipelago

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The Galápagos archipelago, located west of Ecuador, is a good example where a mantle plume interacts with a spreading center and modifies physical and chemical properties of the oceanic lithosphere. The Galápagos Spreading Center (GSC) and the Galápagos hotspot interact over more than 1,000 km with unusual features for a hot spot region (large number of historical active volcanoes, large range of lavas composition, alignment of volcanic centers and seamounts). To bring new information on the physical and chemical properties of this region, we are constructing a new P-wave velocity model of this region by combining data from 10 seismic broadband stations and from 9 MERMAIDS (Mobile Earthquake Recorder in Marine Areas by Independent Divers) deployed in this region between 2014 and 2016. We focus on Pn head waves to better constraint the Moho depth in this region and image the interaction between the hot spot and the GSC. We selected150 seismic events between May 2014 and September 2016, with epicentral distance between $3^{o}$and 35^{o} and picked more than 2,500 Pn phases that we will invert in a probabilistic tomography inversion in a second step. In this presentation, we will show examples and statistics of Pn data. We will discuss the benefits of developing a multi-observable thermochemical tomography in this region to better image the intricate interaction of a hot spot with the overlying oceanic lithosphere and evaluate current physio-chemical evolutionary models.

Keywords: Pn tomography, mantle plume, thermochemical structure

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Effect of iron content on thermal conductivity of olivine with implications for cooling history of rocky planets

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Knowledge of thermal transport properties of mantle materials is essential for understanding the thermal state and dynamics of the Earth and planetary interiors. Previous studies have suggested that temperature and pressure dependences of thermal conductivity can affect mantle convection and plate tectonics involving subduction dynamics. Olivine is the most abundant mineral in the Earth's upper mantle and chemical composition of olivine in the Earth's upper mantle is characterized by high forsterite content around Fo_{90}. For other terrestrial planets, Mercury is believed to have a FeO-poor mantle along with end member silicates, whereas olivine in the Martian mantle would be more Fe-rich, speculated to be Fo_{67}. Recent studies suggested that surface of some asteroids is dominated by olivine of composition from Fo_{49} to Fo_{70}. Hence, the effect of Fe content in olivine on thermal conductivity could be significant for understanding the thermal structure and cooling history of these terrestrial planets and asteroids.

In this study, thermal conductivity and diffusivity of olivine were determined simultaneously by combining multi-anvil high pressure experimental technique and pulse heating method. Thermal properties of olivine with six different Fe contents (Fo, Fo_{90}, Fo_{70}, Fo_{50}, Fo_{31}, Fo_{0}) were measured under the Earth's upper mantle condition in a 5000-ton Kawai type multi-anvil press. The minimum λ was found to be at composition near Fo_{31}; the absolute λ value of Fo_{31} is about 65% lower than that of Fo. Small amounts of minor elements can strongly reduce the thermal conductivity at low temperature; λ value of Fo90 is about 50% of Fo at room temperature. As temperature increases, the difference in λ among olivine samples with various Fe contents tends to become smaller. Thermal conductivities of polycrystalline olivine have smaller absolute values and weak pressure and temperature dependences, compared with those of natural single crystal olivine determined by previous studies. Heat capacity of olivine calculated from λ and κ is independent of pressure and is controlled by nearly constant thermal expansion coefficient of Fo_{70} and Fo_{50} with increasing temperature. Smaller λ of olivine aggregate with high Fe content would produce thicker crust in the Fe-rich Mars, while heat in the Fe-poor Mercury can escape faster than the other terrestrial planets. Olivine-dominant asteroids with high Fe concentration could have longer cooling history and lower thermal inertia on the surface.

Keywords: Thermal conductivity, Olivine, Heat capacity, High pressure, Mantle

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The distribution of Cenozoic conglomerates and its sedimentological constraint on the uplift of the South Tianshan, NW China

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The Cenozoic alluvial fan deposits in the Kuqa Depression of Tarim Basin, likely in response to a tectonic event, can provide critical evidence for constraining the timing of the South Tianshan uplift and reconstructing the paleotectonic evolution of the Central Asian Orogenic Belt. The sedimentological analysis shows that the conglomerates were deposited in alluvial fan environment. The initial uplift stage was started from the Jidike Formation at ~23Ma, resulting only small but angular gravels. Then the rapid uplift was since 15.97 Ma leading to the deposition of Kangcun conglomerate layers. And the next rapid and intensely uplift was started at ~4 Ma of the deposition of Kuqa Formation, according to ~2000m thick alluvial fan conglomerates. After a short quiescence, the most remarkable uplift of South Tianshan regenerated and caused the most extensive alluvial fan conglomerates of Xiyu Formation since 2.58 Ma and continuing to the present.

Keywords: Cenozoic, Central Asian Orogenic Belt, Conglomerate

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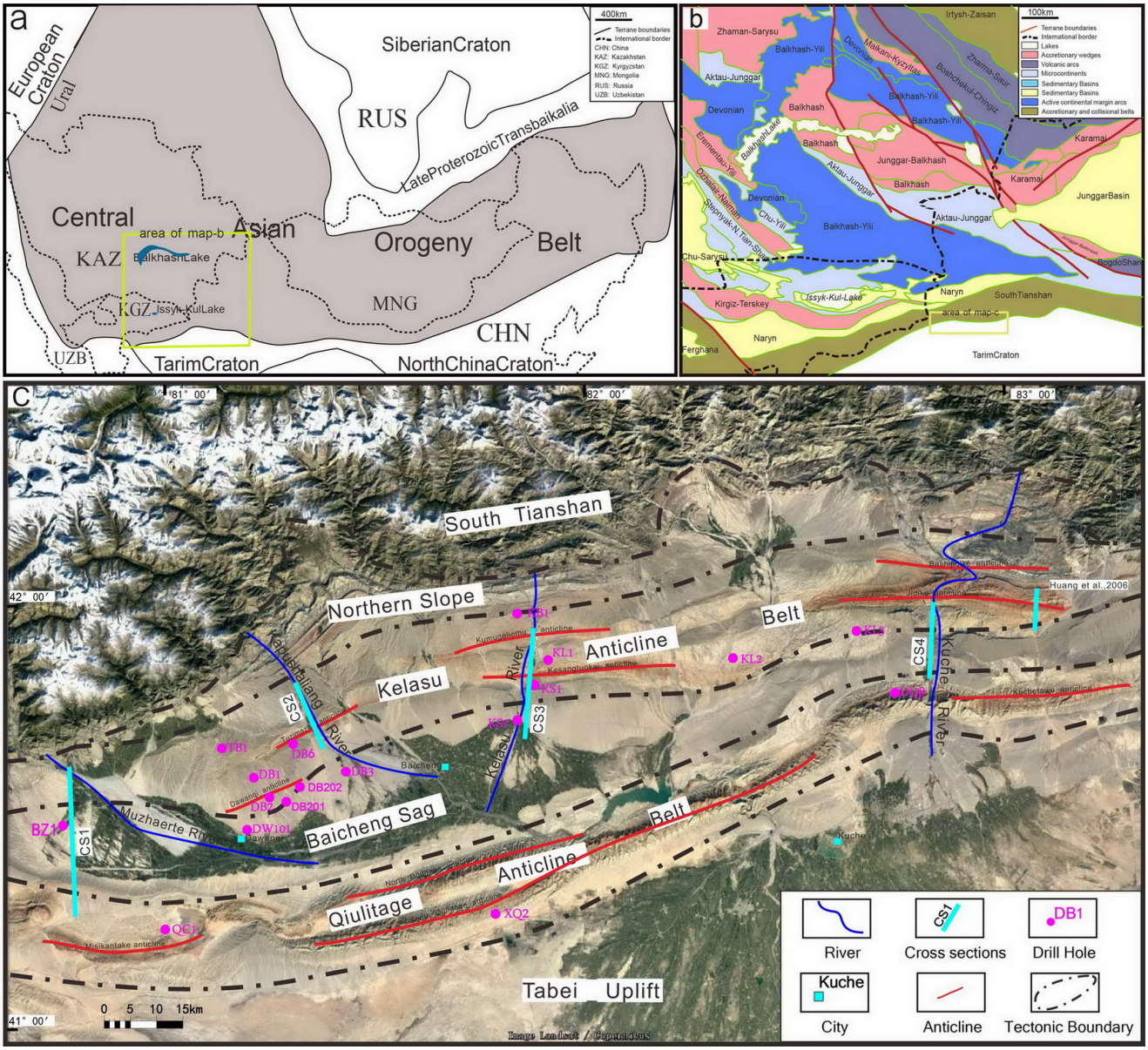

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Electrical conductivity of diaspore, δ-AlOOH and ε-FeOOH

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FeOOH and AlOOH are dominant hydrous phases in sedimentary rocks deposited in the sea or lake basins which were considered to be possibly related to the deep water cycle by slab subduction. Therefore, understanding of the electrical conductivity behaviors of these phases are essential to explore the nature and dynamic process of the Earth's interior. In this study, electrical conductivity of diaspore (α-AlOOH), δ-AlOOH and ε-FeOOH was measured by impedance spectroscopy with a frequency range from 10^{-1} to 10^{6} Hz at pressures up to 15, 20 and 12 GPa and temperatures of 1200, 1200 and 1000 K well below the dehydration temperatures of these phases under the relevant pressures. For diaspore at 8, 10, and 12 GPa, the relationship between electrical conductivity and reciprocal temperature could be well fitted by the Arrhenius formula: $\sigma = \sigma_0 \exp[-(\Delta E + P\Delta V)/kT]$ and shows the pre-exponential factor (σ_0), activation energy (ΔE) and activation volume (ΔV) of 55.94 ±1.16 S/m, 0.547 ±0.016 eV and 1.683 ±0.123 cm^3/mol, respectively. However, data of diaspore obtained below 6 GPa could not be fitted by the Arrhenius formula, which was thought to be due to the remnant of free water in the sample caused by heating to insufficient temperature to proceed dehydration of interstitial water. Thus, it is quite difficult to measure the electrical conductivity of diaspore at low pressures. The electrical conductivity of diaspore increased with pressures ranging from 8 to 12 GPa by half order of magnitude and then the conductivity change with pressures from 12 to 15 GPa became negligibly small. The dominant conduction mechanism of diaspore is regarded as proton conduction. δ-AlOOH and ε-FeOOH show one and two orders of magnitude higher electrical conductivity than diaspore. Due to isostructural $CaCl_2$-type hydroxide structure, δ-AlOOH and ε-FeOOH display the nearly identical activation enthalpy (0.384 ±0.007 eV, 0.330 ±0.048 eV) which is relatively lower than that of diaspore.

Keywords: Electrical conductivity, Diaspore, δ-AlOOH, ε-FeOOH

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Multi-mode surface wave tomography for azimuthal anisotropy in the Australasian upper mantle

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Azimuthal anisotropy in the upper mantle derived from seismic surface waves provides us with the information of mantle dynamics, such as the present-day mantle flow and the remnant of past deformation in the lithosphere and asthenosphere.The Australian plate is currently the fastest-moving tectonic plate including a large continent, encompassed by the intensive seismicity, particularly in its north (Indonesia) and east (Tonga-Kermadec to New Zealand). Thus, the entire continent can be covered by dense ray paths utilizing broad-band seismic stations deployed throughout the continent. This unique tectonic setting of Australian plate allows us to reconstruct high-resolution tomography models in the Australian region (e.g., Fishwick et al., 2008, Tectonics; Yoshizawa, 2014, PEPI).

In this study, we construct new phase speed maps in and around the Australian continent incorporating azimuthal anisotropy for both multi-mode Love and Rayleigh waves using the method developed by Yoshizawa & Kennett (2004, JGR). We employ the data base of path-specific multi-mode phase speeds for the fundamental mode and up to the fourth-higher modes by Yoshizawa (2014, PEPI), which has been measured by using the non-linear waveform fitting method (Yoshizawa & Ekstrom, 2010, GJI). We have performed checkerboard resolution tests as well as jackknife resampling tests, which suggest that our current phase speed data set can provide us with the robust estimation of azimuthally anisotropic phase speed maps in the Australasian region.

The multi-mode phase speed models indicate that the fastest directions of azimuthal anisotropy estimated from the different modes are consistent each other as far as they have the maximum sensitivity at the common depth. Comparisons between the direction of absolute plate motion (HS2-NUVEL-1) by Gripp & Gordon (1990, GRL) and the fastest direction of azimuthal anisotropy suggests that they agree well particularly at around the depth of 100km under the ocean area (Coral and Taman Seas) off the east-coast of the Australian continent and 300km under the continental area of Australia. These results are likely to reflect the differences in the depth of asthenosphere where the effects of the lattice preferred orientation of mantle materials due to the present-day mantle flow can be more significant.

Keywords: Azimuthal anisotropy, Surface wave tomography, Australia

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Mapping multi-mode surface wave phase speeds in North America using mode-branch waveforms decomposed by linear Radon transform

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The use of higher-mode surface waves is inevitable for further enhancement of vertical resolution of tomography model since they are much more sensitive to the deep structure of the Earth’ s upper mantle than the fundamental modes. However, measuring the multi-mode phase speeds is not a straightforward issue since wavetrains of different modes overlap each other in a seismogram.

We have developed the two-step array-based method for higher-mode analysis, which consists of (1) multi-mode phase speed measurements based of a classical *f-k* analysis using a long-range linear array with several-thousand kilometers (e.g., Nolet, 1975, GRL) and (2) modal waveform decomposition for the centroid location of the linear array using the linear Radon transform (e.g. Luo *et al*., 2015, GJI).

We have previously applied the method to a large data set of seismograms observed at Transportable Array stations of USArray and employed the average phase speeds of linear array to map phase speed distributions in North America (Matsuzawa and Yoshizawa, SSJ Fall Meeting 2018; AGU Fall Meeting 2018). We could obtain phase speed maps of the fundamental-mode and the first four higher-mode surface waves. Although the large-scale anomalies (i.e., fast phase speeds in cratons in the stable eastern U.S., slow phase speeds in the tectonically-active western U.S.) can be identified, the lateral resolution of the phase speed maps were insufficient compared to inter-station/array based tomography models. This suggests that the small-scale tectonic features have been blurred and averaged out due to the direct use of long linear array (2000–4000 km) with relatively large measurement errors.

In this study, we apply the inter-station dispersion analysis with nonlinear waveform fitting (Hamada and Yoshizawa, 2015, GJI) to the decomposed modal waveforms of the fundamental-mode surface waves derived from method using the centroids of the linear array as imaginary stations.The lateral resolution of resultant phase speed maps has been improved up to about 2.0 degrees owing to the relatively shorter inter-station (inter-centroid) distances used in the inversions.We can find typical small-scale tectonic features in the inland region of eastern and central US. Average phase speeds along each short ray path (several-hundred kilometers) have been measured stably without interference by overtones, which is likely to be of help in improving the accuracy of the resultant tomography maps.

The decomposed modal waveforms of the higher modes as well as the fundamental mode can be applied to the secondary dispersion analyses such as the inter-station dispersion measurements as done in this study and/or a 2-D beamforming analysis, which can be expected to enhance both the lateral and vertical resolutions of surface wave tomography models.

Keywords: Surface wave, Higher mode, Array-based analysis, Tomography, North America

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Radial anisotropy in the upper mantle using multi-mode surface waves incorporating the η_κ parameter: Application to the Pacific and Australian regions

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Radial anisotropy can be described by five elastic parameters; four parameters related to seismic wave speeds (β_v, β_h, α_h, α_v) and an additional fifth anisotropic parameter (η). One of the anisotropic parameters, η, was originally defined by Anderson (1961), but its physical proprieties have been rather unclear compared with other four parameters related to elastic velocity.

The re-defined fifth anisotropic parameter η_κ by Kawakatsu et al. (2015) makes it easier to understand its physical proprieties compared with conventional η. The introduction of η_κ affects the shape of sensitivity kernels of Rayleigh wave phase speeds with respect to η_κ, PH-wave speeds α_h and PV-wave speeds α_v (Kawakatsu, 2016b). Since the sensitivity of Rayleigh wave phase speeds to η_κ becomes greater than that to η, we can expect a possibility of resolving the η_κ parameter. However, since the inverse correlation between the sensitivity kernels of SV-wave speed β_v and η_κ becomes rather stronger, the trade-off between β_v and may easily occur. Therefore, the independent determination of η_κ parameter from the inversions of surface-wave dispersion curves is not a straightforward issue.

In this study, incorporating η_κ, we performed inversions for five elastic parameters in the upper mantle, employing a classical iterativenonlinear least-squares inversion method (Tarantola and Valette, 1982). We used multi-mode dispersion data sets of surface waves in the Australian region (Yoshizawa, 2014, PEPI) and Pacific (Isse et al., 2019, EPSL) to reconstruct 3-D radially anisotropic model. In these inversions, we used isotropic PREM as a starting model to avoid the influence of reference anisotropy model.

The retrieved spatial distribution of the η_κ parameter can be mostly explained by trade-offs with SV wave speed β_v at many locations in Australia and Pacific. Still, we can find structural features in our 3-D β_v and η_κ models, particularly in some major structural boundaries such as ridges and the Tasman Line in eastern Australia, which cannot simply be attributed to the trade-off between β_v and η_κ, indicating possible intrinsic character of η_κ in the upper mantle.

Keywords: radial anisotropy, surface waves, inversion

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Pure to impure and dry to wet olivine rheology based on high temperature dependency of diffusion creep

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There has been a large discrepancy in creep properties of olivine aggregates in dry diffusion creep regime between Minnesota group (Hirth and Kohlstedt, 1995) and ANU group (Faul and Jackson, 2007). Our recent deformation experiments on undoped and doped olivine aggregate synthesized by a new method different from previous studies demonstrate (i) the activation energy of grain boundary diffusion creep of undoped olivine is 465 kJ/mol, (ii) the creep rate is enhanced by doping of Ca and Al above ~1200 C with very high temperature sensitivity well represented by activation energy of ~700 kJ/mol, and (iii) presence of melt phase had little contribution to the change in the creep strength. Such observations are consistent with Yamauchi and Takei (2016) which attributed the observation to pre-melting at near solidus.

In this study, we compile all rheological data of olivine diffusion creep based on solidus which changes with the chemical compositions and amount of water. The solidi of dry samples are estimated from experiments and/or phase diagrams. The solidi of wet samples are calculated by cryoscopic approach following Hirshmann et al. (2009). We demonstrate that not only dry but also wet data are well explained by the operation of grain boundary diffusion creep with activation energy of 465 kJ/mol at <~0.93 × solidus and 700 kJ/mol at >~0.93 ×solidus. The controversy on the effect of water on grain boundary diffusion by Mei and Kohlstedt (2000) and Fei et al. (2016) is explained by the experimental temperatures with respect to the solidus of their systems. The viscosity depth profile in the upper mantle based on our new diffusion creep model will be presented.

Keywords: mantle rheology, olivine aggregates, diffusion creep

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Finite frequency S wave tomography model beneath the Ontong Java Plateau using data recorded by broadband ocean bottom seismographs

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1. Japan Agency for Marine-Earth Science and Technology, Yokosuka, Japan, 2. Earthquake Research Institute, The University of Tokyo, Tokyo, Japan, 3. The University of Kobe, Hyogo, Japan

We determined three-dimensional S wave model beneath the Ontong Java Plateau (OJP) by finite frequency tomography using data recorded by broadband seismographs deployed at ocean bottom covered the OJP and at neighbor islands (Suetsugu *et al.*, 2018). Our dataset contains absolute and period-depended differential travel time data. The former consists of ~1,100,000 direct S-wave onset times reported by International Seismological Centre (ISC) and ~400 direct S-wave onset times picked up on broadband waveform records around the OJP and the latter is composed of ~3,000 differential traveltimes between two different stations around the OJP measured by waveform cross correlation at 7 different passband of which center periods varies from 5.3 sec to 42 sec. We used adaptive stacking method (Rawlinson and Kennett, 2004) to measure absolute travel time data near the OJP. These data were inverted based on the infinite frequency travel time tomography method for the absolute travel time data (Inoue *et al.*, 1990; Fukao *et al.*, 1992; Obayashi *et al.*, 2013) and the finite frequency travel time method for the relative travel time data (Dahlen *et al.*, 2000; Obayashi *et al.*, 2013). We obtained a well resolved S wave velocity model beneath the OJP. It shows significant high velocity anomalies in the mantle transition zone, which are considered as stagnant Pacific slabs related to the trench retreating as well as seafloor spreading in the Santa Cruz Basin and Melanesia Basin during the Eocene and Oligocene. It also reveals that S wave velocity just below the OJP is a little higher than the surrounding strong slow anomalies in the mantle shallower than 200 km. We will discuss these remarkable features beneath the OJP in comparison with P wave tomographic model (Obayashi *et al.*, 2018) in this presentation.

Keywords: finite frequency tomography, S wave velocity structure

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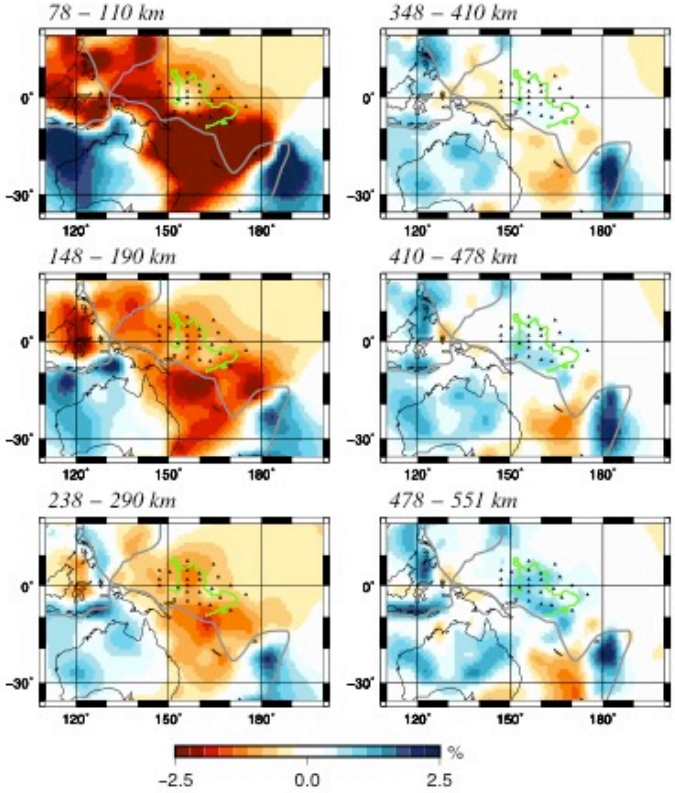
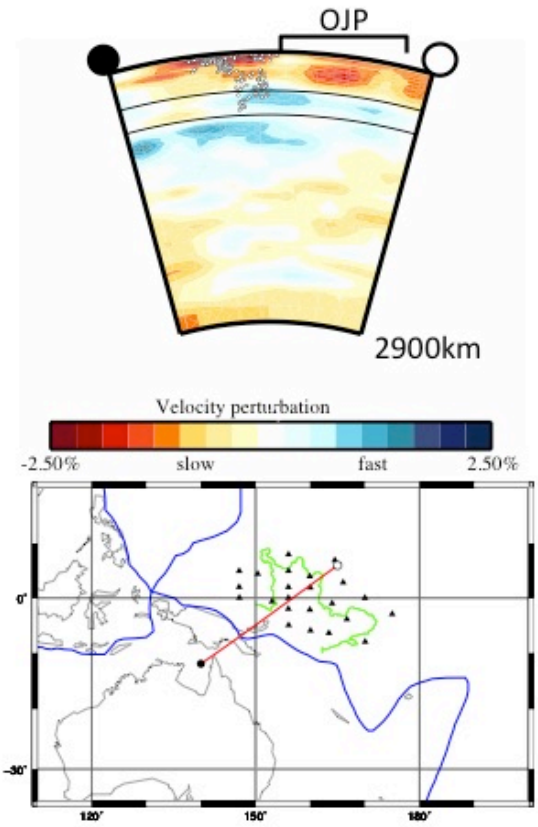
(a)



(b)



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Shear wave structure of the upper mantle beneath the Ontong Java Plateau

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Ontong Java Plateau (OJP) is the vastest Large Igneous Provinces (LIPs) in the oceanic region of the Earth. The OJP was emplaced at 122 and 90 Ma by massive volcanism, but the origin of this volcanism is still under discussion.
Richardson et al. (2000) obtained a large low-velocity root of the OJP extending as deep as 300km, though its existence and cause are still in debating.
One reason for poor understanding of the OJP is the insufficient information about the crust and mantle structure beneath the OJP because of the lack of long-term seafloor observation. Between 2014 and 2017, we conducted the first seismological and electromagnetic observations on the seafloor and islands in the OJP, named "OJP array", to clarify the origin of the OJP.
Using the broadband data from the OJP array as well as those from stations on land and seafloor in the western Pacific Ocean, we constructed three-dimensional shear wave speed structure beneath the OJP by surface wave tomography. using phase speed dispersions of Love and Rayleigh waves up to the 4th higher modes. Checkerboard resolution tests suggests that the spatial resolution of the obtained model is ~300km, which is higher than previous studies.

Obtained shear wave speed structure down to the depth of 300 km shows the following new features:
(1) In the center of the OJP at depths between 70–150 km, about 2% fast anomalies exists;
(2) No strong slow anomaly is found beneath the OJP at depths down to 300 km;
(3) Beneath the Caroline Islands, in the north of the OJP, 2 % slow anomalies exist, which may be associated with the Caroline hotspot activity.

These newly found features suggest that further investigation to reveal the origin of the OJP is necessary.

Keywords: upper mantle structure, Ontong Java, surface wave tomography, BBOBS

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Effect of impurity on post-post-perovskite transition of $MgSiO_3$ by first principles

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Several computational studies have predicted post-post-perovskite transitions in MgSiO3 at ultrahigh pressures and temperatures which can occur at deep interiors of super-Earths: $MgSiO_3$ --> Mg_2SiO_4+ $MgSi_2O_5$ --> Mg_2SiO_4+ SiO_2 --> MgO + SiO_2) and recombination (MgO + $MgSiO_3$ --> Mg_2SiO_4 or SiO_2 + $MgSiO_3$ --> $MgSi_2O_5$) [1-5]. As demonstrated in a very recent numerical simulation, these transitions are crucially important in modeling interiors of super-Earths up to 20 times Earth’ s mass [6]. However, in the previous studies, these post-post-perovskite transitions were considered only for pure Mg-Si-O. In actual super-Earths, impurities, Fe, Al, or so forth, should exist. Here we will investigate effects of impurities on post-post-perovskite transitions: transition pressures, local atomic structures, and equation of states.

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Keywords: super-Earth, post-post-perovskite transition, first principles

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Unsusual high-Ti corundum recovered from the Horoman peridotites, Hokkaido, Japan

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1. yokohama national university

Oceanic and continental crust are recycled into the mantle due to subduction of oceanic plate in the mantle, and the crustal materials are thought to be mixed in the mantle through mantle convection (W.Xu et al., 2008). However, the mode and process of crustal mixing in peridotites are unknown, and constraints using recycled crust minerals are needed for elucidating the mantle-crust circulations. Horoman peridotites, located in the Hidaka Mountains of Hokkaido, is known as a fresh peridotite that is less serpentinized. By the metasomatism of the melt-mantle reaction, the harzburgite-lherzolite shows a remarkable stratigraphic structure. Recently, the occurrence of crustal minerals has been reported by Li et al., (2017) from the Horoman peridotites, such as zircon, rutile, diamond with a low carbon isotopic ratio, suggesting that these crustal minerals in the Horoman peridotites have recycled origin due to the past subduction and mixing in the mantle. However, the origin of crustal minerals in the Horoman peridotitare unclear, and few recovered cases. To better understand the origin of crustal minerals in the Horoman peridotites. we improve the mineral separation techniques and recovered unusual Ti-rich corundum from the Horoman peridotite. describe the separated minerals in details.

In this study, peridotite samples collected from the quarry of Toho Olivine Industry Co., Ltd., were employed for the heavy mineral separations. Each peridotite samples, 764 kg of harzburgite and 954 kg of lherzolite, were cut to a plate shape and transported to the Yokohama National University. Using a jaw crusher and a continuous crusher, it was crushed to 0,1 mm in size and then subjected to sieving, gravity, and magnetic separations, and finally hand picking the remaining minerals, which embedded in epoxy resin and polished. Six zircons, one rutile (TiO_2) were recovered from within the lherzolite. On the other hand, grains recovered from nonmagnetic fraction harzburgitewere embedded for mineral exploration using EPMA , and as a result, twelve corundum (Al_2O_3) grains were discovered. Inclusions and attached minerals coexisted in corundum were observed under the stereoscopic microscope. SEM-EDS analysis of six corundum grains confirmed that inclusions and attatched phase consisting of (1) Si-Al-K rich silicate, (2)Ti-Zr oxide,aand (3) Si-Ti alloy.

Morishita et al., (1998; 2000) previously reported the corundum xenocryst containing a trace amount of Cr from the gabbro boulder in the Ponsanushibetsu river in Samani town. This corundum is interpreted as a metamorphic product of gabbro protolith or xenocrust from the Hidaka crust. The characteristics of corundum obtained in this study is (1) almost no Cr, (2) unusual high-Ti content (maximum 2.3 wt% of TiO_2), (3) unique inclusions such as Ti-Zr oxide and Si-Ti alloys. Therefore, it is thought that a corundum recovered from the Horoman peridotite have different origin from that of Morishita et al. (1998; 2000). In another case, corundum with high TiO_2 concentration and specific inclusion (Ti-Zr oxide, Ti-Si alloy) has been reported from xenocrysts related from alkaline basalts of Israel Mt.Carmel (Griffine et al., 2016; 2018). Origin of Mt. Carmel corundum is still unclear, but tentatively proposed to be crystallized from mafic to ultramafic melt near the crust-mantle boundary under the highly reducing conditions (Griffine et al., 2018) The discovery of unusual high-Ti corundum from the Horoman peridotites will shed light on significant petrological issue on peridotite studies.

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Keywords: mantle peridotite , recycle, corundum, Titanium

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Deformation experiments on akimotoite

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The ilmenite structure of $MgSiO_3$, known as akimotoite, is inferred to occur in cold subducting slabs in the bottom of Earth's mantle transition zone and the uppermost lower mantle along a low-temperature geotherm (Akaogi et al., 2002). Akimotoite is thought to be the most anisotropic mineral in the Earth's mantle transition zone (Zhang et al., 2005; Weidner & Ito,1985). The elastic anisotropy caused by the lattice preferred orientation of akimotoite due to slab-induced deformation may be used plausibly to interpret the significant seismic anisotropy observed in mid-mantle (depths 410-670km) (Nowacki et ali.,2015; Foley & Long, 2011). However, previous studies did not determine the slip plane or the dominant slip system precisely (Shiraishi et al., 2008). In this study, therefore, we conducted deformation experiment on akimotoite aggregates to investigate precise and detailed microstructures. For the preparation of starting material of akimotoite aggregates for deformation experiment, high pressure experiments using $MgSiO_3$ glass as starting material have been performed at 20-22GPa and 1400 ℃, in the Kawai-type multi anvil apparatus. The recovered samples were investigated by X-ray diffraction, electron probe microanalysis and scanning electron microscopy to identify phase, measure chemical composition and observe microstructure, respectively, showing that samples were well-sintered and no-crack akimotoite aggregates with grain size of 2-8 μm. These akimotoite aggregates were suitable as a starting material for deformation experiments. We subsequently conducted pure shear deformation experiment on such akimotoite aggregates at ~21 GPa and 1200 ˚C by using high pressure deformation apparatus, so called D-111 type apparatus, installed at Institute for Planetary Materials, Okayama University. The relationship between displacement and load of D-rams may suggest the mechanism change from elastic to plastic deformation with the progress of deformation. As a result, we observed the plastic deformation on the recovered sample and the strain and average strain rate were estimated to be ~0.12 and ~1.6×10^{-5} s^{-1}, respectively. It is considered that the strain of ~0.12 is sufficient to form the lattice preferred orientation which can be analyzed by electron backscattered diffraction technique.

Keywords: akimotoite, lattice preferred orientation, deformation at high pressure, anisotropy , mantle

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Fate of water in subducted hydrous sediments deduced from stability fields of FeOOH and AlOOH up to 20 GPa

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1. Institute for Planetary Materials, Okayama University, 2. Department of Earth Sciences, University of Oxford, 3. Department of Geosciences, Princeton University

Fe- and Al-hydroxides (FeOOH and AlOOH) in sedimentary rocks form the top part of the subducted oceanic lithosphere and are known to be stable along a normal geotherm in the lower mantle. Banded Iron Formations (BIFs) and bauxite ore deposits formed in the Earth’s oceans can transport significant amount of water into the Earth’s deep interior by subduction of FeOOH and AlOOH and may occasionally serve water to the core. However, stabilities of these hydrous phases have not been well constrained in upper mantle conditions. We determined dehydration curves for FeOOH and AlOOH in upper mantle and mantle transition zone conditions (5–20 GPa, 673–1573K)by quench and *in situ*X-ray diffraction to constrain their capability of water transport to the deep mantle. Dehydration temperatures of these minerals increase with increasing pressure. Comparison between our results and geothermal gradients of subducting slab surfaces demonstrates dehydration of FeOOH in early subduction stage (around 2 GPa). In most cases, diaspore (AlOOH) also dehydrates in early subduction. Despite the implications of the stability of these phases at high pressure, our results show that the sediments located at the slab surface are unlikely candidates for transporting water to the deep mantle.

Keywords: water, sediment, dehydration, hydrous minerals, subduction

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[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT23] Structure and Dynamics of Earth and Planetary Mantles

convener:Takashi Nakagawa(Department of Earth Sciences, The University of Hong Kong), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Dapeng Zhao(Department of Geophysics, Tohoku University), Chairperson:Takashi Yoshino(Okayama University)

Interdisciplinary approach can lead to a better understanding of dynamics and evolution of the deep interiors of the Earth and planets. We welcome any submissions of recent results in observational, theoretical and experimental studies on seismology, geomagnetism, mineral physics, dynamics of deep interiors, and any other relevant fields from researchers in many countries. Integration of such results is also welcome. In particular, we encourage any contributions focusing on "plate and mantle dynamics in Earth and terrestrial planets". We also encourage papers stimulating an interdisciplinary collaboration relating to establishment of the Japan-SEDI community.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SIT23-01] In search of recycled continental crust in the Mantle Transition Zone using geoneutrino measurements

*William F McDonough[1], Bedrich Roskovec[2], Ondrej Sramek[3] (1.Tohoku University, Sendai, Japan, 2.Universidad Catolica de Chile, Santiago, Chile, 3.Charles University, Praha 8, Czech Republic)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SIT23-02] Tectonic plates in 3D-numerical models of mantle convection with stress-history-dependent viscosity

*Takehiro Miyagoshi[1], Masanori Kameyama[2], Masaki Ogawa[3] (1.Japan Agency for Marine-Earth Science and Technology, 2.Ehime University, 3.University of Tokyo)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SIT23-03] Denoising S-Net Data to Image the Japan Trench: Comparisons to Alaska and Cascadia

*Claire Diane Doody[1,2], Qingkai Kong[1,2], William Scott[3], William Bythewood Hawley[1,2], Robert Martin-Short[1,2], Richard M Allen[1,2] (1.UC Berkeley, 2.Berkeley Seismo. Lab, 3.Imperial Coll. London)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SIT23-04] **Experimental confirmation of a spineloid transitional olivine polymorph using ultrafine-grained aggregates of Mg_2GeO_4**

*Thomas P. Ferrand[1], Takehiko Hiraga[1] (1.Earthquake Research Institute)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SIT23-05] Effects of fine-scale laminated heterogeneity on seismic anisotropy from long-period surface waves: Evaluation with two-dimensional waveform modelling

*Xu Yunao[1], Kazunori Yoshizawa[1,2], Takashi Furumura[3] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, Japan , 2.Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, Japan, 3.Earthquake Research Institute, The University of Tokyo, Japan)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SIT23-06] **Redox kinetics of olivine revealed by diffusion profile of oxygen fugacity and its implication to the redox evolution of the uppermost mantle**

*Chengcheng Zhao[1], Takashi Yoshino[1] (1.Institute for Study of the Earth's Interior, Okayama University)

In search of recycled continental crust in the Mantle Transition Zone using geoneutrino measurements

*William F McDonough[1], Bedrich Roskovec[2], Ondrej Sramek[3]

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Plate tectonics provides the framework for understanding the modern evolution of the crust and mantle system, with subduction zones linking these two major domains of the silicate Earth. Sediment recycling into the mantle at subduction zones is well established, although unknowns (e.g., past and present-day rates, amounts, depth of recycling, etc) remain significant. The present day subduction zone settings include ocean-ocean, ocean-continent, and continent-continent collisions and each of these likely have differing degrees of efficiencies of sediment recycling, as evidence by distinct differences in the remnants of meta-sediments exposed in fossil forearc regions of different collision zones. The retrieved metamorphic record of ocean-ocean and ocean-continent collision zones documents meta-sediments experiencing high-grade (granulite to eclogite facies) metamorphism. In contrast, continent-continent collisions return meta-sediments having experienced ultrahigh-grade (up to diamond facies) metamorphism. What is not known is the effectiveness of deep sediment recycling, past the magmatic zone, in each of these three different convergent margins.

Models that envisage successful subduction channel transport of upper crustal materials below 300 km depth, past a critical phase transition in buoyant crustal lithologies, are capable of accumulating and assembling these materials into so-called “second continents" that are gravitationally stabilized at the base of the Transition Zone, at some 600 to 700 km depth [Kawai et al., 2013]. Global scale, Pacific-type subduction (ocean-ocean and ocean-continent convergence), which lead to super continent assembly, were hypothesized to produce second continents that scale to about the size of Australia, with a maximum potential of continental upper crustal concentration levels of radiogenic power. Seismological techniques are incapable of imaging these second continents because of their negligible difference in seismic wave velocities with the surrounding mantle. We can image the geoneutrino flux linked to the radioactive decays in such hypothesized continental lithologies with land and/or ocean-based detectors. We present predictions of the geoneutrino signal for these continental lithologies, assuming different scaled models and show that the combination of the KamLAND-JUNO-Jinping neutrino experiments are strategically positioned to discover or constrain a predicted second continent beneath eastern China. The power emissions from such second continents were proposed to be drivers of super continental cycles. Thus, testing models for the existence of continental lithologies in the Mantle Transition Zone will place constraints on mantle and plate dynamics when using land and ocean-based geoneutrino detectors deployed at strategic locations.

Keywords: mantle transition zone, geoneutrino, second continent, heat producing elements, sediment subduction

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Tectonic plates in 3D-numerical models of mantle convection with stress-history-dependent viscosity

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We present a three-dimensional numerical model of plate tectonics (Figure 1; grayscale shows viscosity and arrow shows velocity). Tectonic plates steadily move on the Earth, because the lithosphere “remembers” the plate boundaries formed by its rupture that took place in the past: Once the stress in the lithosphere exceeds a threshold, the lithosphere is rifted, a sharp plate boundary develops, and the adjacent plates begin to rigidly move with respect to each other. This plate boundary and the resulting relative plate motion persist, even after the stress is reduced below the threshold around the plate boundary. We developed a model of this stress-history dependent nature of the rheology, and implemented the model to our three-dimensional numerical model of mantle convection (ACuTEMAN) in an internally heated rectangular box of 3000 km in depth and 12000 km×12000 km in horizontal dimensions. In our models, the lithosphere is rifted into several pieces, each of which rigidly moves and rotates, as observed for the Earth. The deformation of the lithosphere concentrates to narrow plate margins where the vertical component of rotation of the velocity field takes large values. The plate margins persist and allow the relative plate motion across the margin for billions of years. The heat flow takes a high value at spreading centers, and declines with the distance from the centers in their vicinity. Away from the centers, however, the heat flow tends to a steady value that is determined from the secondary convection that occurs beneath the tectonic plates as rolls with their axis aligned in the direction of plate motions.

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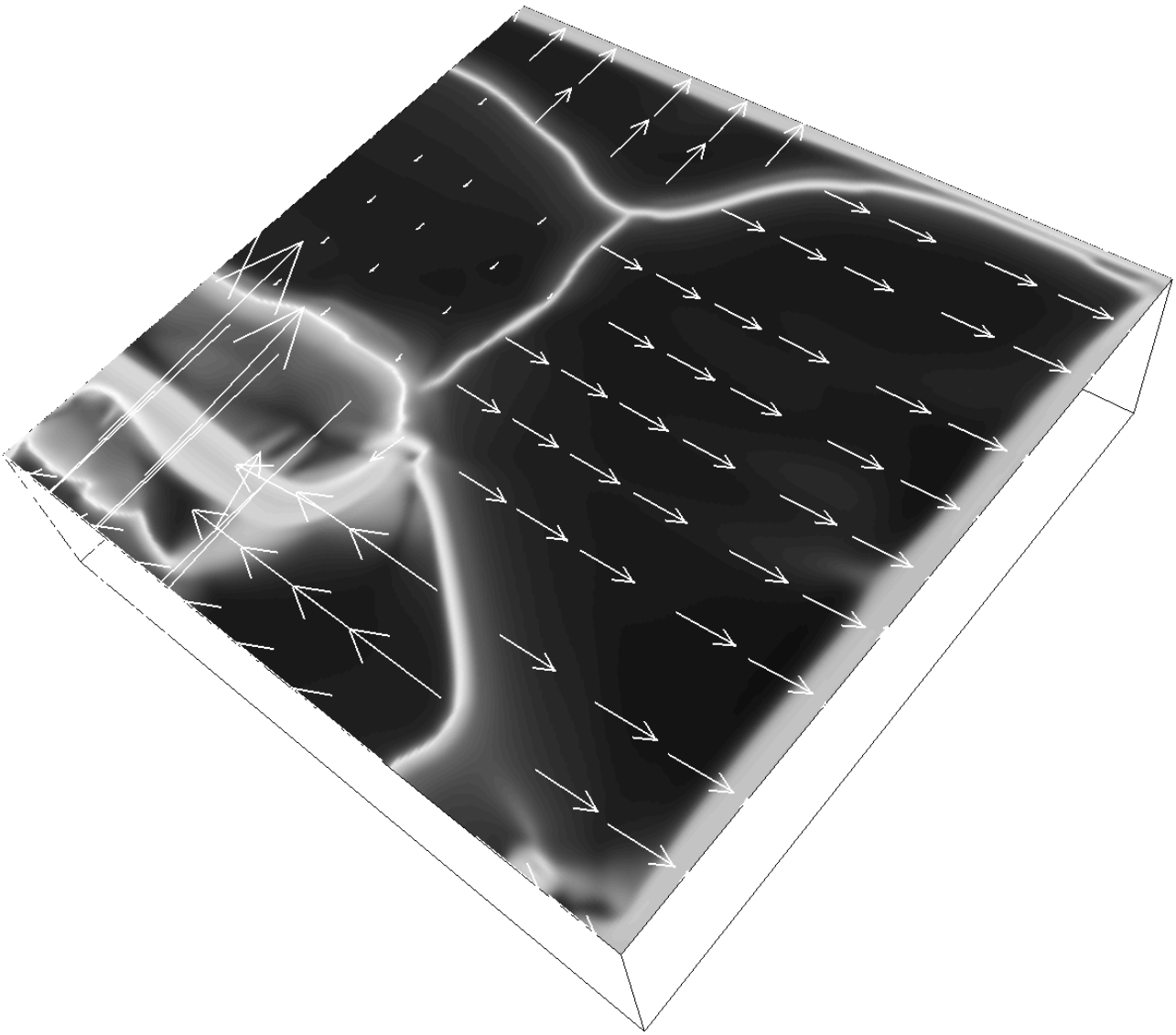

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Denoising S-Net Data to Image the Japan Trench: Comparisons to Alaska and Cascadia

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The release of the S-Net data by NIED has created access to a wealth of information for seismologists. However, the S-Net data is inherently noisy due to its placement on the ocean floor. To suppress noise within the data, we have modified the deep-learning approach taken by Zhu et al., 2018 to denoise the S-Net data; we assembled data from on-land Hi-Net stations as the “clean” training dataset, and added the S-Net data as its noisy counterpart. This denoised data set is used to extract compressional wave arrival times to create a high-resolution image of the Japan Trench in hopes of better understanding the structure of the uppermost 200km of the mantle. The structure of the Pacific Slab is compared to Alaska and Cascadia to compare subduction zone features using identical methods. By directly comparing Japan, Alaska, and Cascadia, we seek to make a preliminary attempt at exploring comparable features in these subduction zones to work towards a more unified view of subduction zone processes.

Keywords: S-Net, Machine Learning, Japan Trench

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Experimental confirmation of a spineloid transitional olivine polymorph using ultrafine-grained aggregates of Mg_2GeO_4

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Ultrafine-grained aggreagtes of Mg_2GeO_4 were synthetized using spark plasma sintering and deformed using an 1-atm deformation rig between 950˚C and 1200˚C. Observations with SEM, EBSD, XRD and Raman together confirm that the samples consist of α-olivine with minor enstatite, with a grain size of 1-10 microns. Deformation data indicate an extreme softening of the material around 100 MPa in samples deformed at temperatures of 1000˚C or above. This softening is followed by a sharp hardening, suggesting that the fast deformation process ended.
The olivine-spinel transition in Mg_2GeO_4 occurs around 810˚C, and all experiments were done in the stability field of olivine. The deformation curves, supported by Raman and XRD data, suggest that ω-olivine, expected by Poirier in 1981, and observed in Mg_2GeO_4 within a meteorite in 2017, transiently forms during the deformation. ω-olivine is a spineloid metastable olivine, which does not have any stability field in a P-T diagram, but it might have one in a P-T-σ diagram. It was reproduced in the stability fields of β-olivine (Guyot et al., 1991) of γ-olivine (Reynard et al., 1994). Here I show that it can also form in the stability of α-olivine.
It seems that the transition occurs only between 1000˚C and 1150˚C when the stress approaches 100 MPa, as a result of a competition between diffusional and displacive processes.
The existence of ω-olivine in stressed mantle regardless of stability fields could have major consequences on how we understand the solid-state olivine-spinel transition and related earthquakes triggering. Below 1200˚C, if ω-olivine does not form then α-olivine is metastable.

Keywords: olivine-spinel transition, ω-olivine, mantle, laboratory, metastable, martensitic

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Effects of fine-scale laminated heterogeneity on seismic anisotropy from long-period surface waves: Evaluation with two-dimensional waveform modelling

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Recent seismic studies using long-period surface waves have revealed lateral variations of radial anisotropy in the lithosphere and asthenosphere (e.g., Nettles & Dziewonski, 2008; Yoshizawa, 2014). Such radial anisotropy estimated from long-period surface waves can be linked partly to the existence of fine-scale laminated structure suggested by recent high-frequency body wave studies (e.g., Kennett et al., 2017).

The aim of this study is to investigate quantitative relationship between such fine-scale laminated heterogeneity and observed radial anisotropy through synthetic experiments with numerical simulations of seismic wavefields. Quantifying the effects of fine-scale heterogeneity on total seismic anisotropy will allow us to estimate the proportions of “apparent anisotropy” (caused by heterogeneity) and “intrinsic anisotropy” (the elastic properties of the medium) that are generally mixed up in observed seismic anisotropy from long-period surface waves.

To investigate the effects of fine-scale laminated heterogeneity on long-period surface waves, we performed a series of 2-D finite-difference method simulations using velocity models with a variety of wavenumber spectrum of random heterogeneity based on von Karman distribution function with varying horizontally-elongated correlation scales. Following the earlier works of Kennett and Furumura (2008, GJI), we considered finely laminated heterogeneities with RMS 2% velocity deviations from PREM in the depth between Moho and 100 km. While the vertical correlation scale is fixed to 0.5 km in 2-D vertical structure along propagation paths, we have changed horizontal correlation scales from 10 km (as suggested by Kennett & Furumura, 2008) to 2000 km (almost equivalent to a 1-D velocity profile).

Using about 100 synthetic seismograms located at the epicentral distances between 2000 and 4000 km for each model, average phase velocities of the fundamental-mode Love and Rayleigh waves are measured using inter-station waveform fitting method (Hamada & Yoshizawa, 2015, GJI). By comparing the average inter-station phase velocities between different models, we investigate the effects of finely-laminated heterogeneity with various horizontal correlation length on the apparent radial anisotropy of surface waves.

Through these numerical experiments, we have found that the horizontal correlation length of laminated random heterogeneity strongly affects the apparent seismic anisotropy; i.e., extending the horizontal correlation length will make the apparent radial anisotropy greater. While the Love wave phase velocities are less affected by such random heterogeneity with any scales, Rayleigh wave phase velocities drop about 0.5-0.6 % slower than the isotropic case in the period range 40-70 s for a relatively long horizontal correlation length (2000 km). Such effects become weaker for a short horizontal scale (10 km), and phase velocity drop of Rayleigh waves is reduced to about 0.1 %. These results indicate that finely laminated heterogeneity with intermediate horizontal scale (several hundred kilometers or greater) may cause

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non-negligible influence on phase velocity drop of Rayleigh waves, as suggested by observation of scattering and guiding of high-frequncy seismic waves traveling through lithosphere (e.g., Kennett & Furumura, 2015), generating apparent radial anisotropy of S-waves in the upper mantle.

Keywords: Heterogeneity, Seismic anisotropy, Forward modelling, Surface waves

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Redox kinetics of olivine revealed by diffusion profile of oxygen fugacity and its implication to the redox evolution of the uppermost mantle

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1. Institute for Study of the Earth's Interior, Okayama University

The evolution of the redox state of the mantle through time has been a focus of hot debate. Recent study implies that the redox budget of the slab may not be significantly changed during subduction [1]. Thus, ferric iron transported by oxidized slab is expected to change the redox state of the upper mantle. However, concentrations of Cr, V, and the V/Sc ratio of the oldest known rocks indicate that the upper most mantle has remained at approximately FMQ over the past 3.5 Gyrs [2, 3]. Therefore, it seems that although oxidized slab is continuously subducted into mantle, the redox state of the upper mantle does not change systematically. It is possible that the mantle represents an almost infinite buffer reservoir and renders the addition of oxidized slab ineffective. On the other hand, the possible extremely slow reaction speed between slab and the uppermost mantle materials might disable the oxidized component to be an effective redox changer. However, the mechanism of the interaction between them remains unclear, which is of great urgent to investigate.

Olivine (MgO, SiO_2 and Fe_2O_3 oxide mixture) with 5 wt% Pt powder used as oxygen sensor was first synthesized using gas mixture furnace at iron-wustite (IW) buffer and Ni-NiO (NNO) buffered condition at 1300 °C. Diffusion couple method is adopted to investigate the redox kinetics of olivine, within which pre-sintered piece of oxidized and reduced olivine was stacked face to face. Diffusion experiments were conducted for different durations at 1 GPa, 1100-1300 °C using piston cylinder apparatus. After recovery, oxygen fugacity profiles were calculated from iron fraction in Pt alloy and iron content in olivine measured by EPMA [4]. Diffusion coefficients were obtained using Boltzmann-Matano method through fitting and calculation of iron content in Pt alloy as a function of distance from Matano interface. Water content after diffusion was measured using FTIR.

Except one couple, the water content of all the other couples shows < 10 wt. ppm. Redox process in olivine could be viewed as a diffusion-controlled process. Diffusion coefficient in oxidized olivine shows obvious oxygen fugacity dependence, while that in reduced one shows small dependence. The activation enthalpy is calculated to be 235 kJ/mol, which is comparable with that for Fe-Mg diffusion in olivine. However, the magnitude is 2-4 orders higher. Since the activation enthalpy and magnitude are comparable with that of diffusion of hydrous defects related to Mg-vacancies [5], it is possible that even extremely small amount of water could dominate redox kinetics in olivine. The diffusion length calculated indicate that the influence exerted by slab on the reduced mantle is very limited (< 4 km at 1600 °C even for 4500 Ma’ s stagnation in the upper mantle). Therefore, it is possible that the extremely slow redox process prevents subducted slab to change the redox state of the upper mantle. Once subducted more, the oxidized slab can bring redox budget to deep mantle as it keeps dry condition.

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Keywords: Redox kinetics , Olivine, Diffusion , Subducting slab, Upper mantle

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[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT23] Structure and Dynamics of Earth and Planetary Mantles

convener:Takashi Nakagawa(Department of Earth Sciences, The University of Hong Kong), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Dapeng Zhao(Department of Geophysics, Tohoku University), Chairperson:Dapeng Zhao(Tohoku University)

Interdisciplinary approach can lead to a better understanding of dynamics and evolution of the deep interiors of the Earth and planets. We welcome any submissions of recent results in observational, theoretical and experimental studies on seismology, geomagnetism, mineral physics, dynamics of deep interiors, and any other relevant fields from researchers in many countries. Integration of such results is also welcome. In particular, we encourage any contributions focusing on "plate and mantle dynamics in Earth and terrestrial planets". We also encourage papers stimulating an interdisciplinary collaboration relating to establishment of the Japan-SEDI community.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SIT23-07] Reactive Melt Channelization in the Earth's Mantle

*Matej Pec[1], Benjamin Holtzman[3], Mark Zimmerman[2], David Kohlstedt[2] (1.Massachusetts Institute of Technology, 2.University of Minnesota, 3.Lamont-Doherty Earth Oservatory, Columbia University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SIT23-08] Deep structure and origin of the intraplate volcanoes in Northeast Asia

*Dapeng Zhao[1] (1.Department of Geophysics, Tohoku University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SIT23-09] 3D passive-source reverse-time migration imaging of mantle discontinuities

*Yang Shen[1], Jiahang Li[1], Hitoshi Kawakatsu[2] (1.Graduate School of Oceanography, University of Rhode Island, USA, 2.Earthquake Research Institute, University of Tokyo)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SIT23-10] Configuration of slab beneath Ogasawara Islands and P-wave time differences between high and low frequencies

*Keiko Kuge[1] (1.Department of Geophysics, Graduate School of Science, Kyoto University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SIT23-11] Cool lower mantle transition zone inferred from seismic anisotropy of deformed ringwoodite

*Takaaki Kawazoe[1,2], Florian Heidelbach[2], Nobuyoshi Miyajima[2], Takayuki Ishii[2] (1.Hiroshima Univ., 2.Univ. Bayreuth)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SIT23-12] Crystal chemistry and compressibility of $Fe_{0.5}Mg_{0.5}Al_{0.5}Si_{0.5}O_3$ and $FeMg_{0.5}Si_{0.5}O_3$ silicate perovskites at pressures up to 95 GPa.

*Iuliia Koemets[1], Zhaodong Liu[2], Egor Gennadievich Koemets[1], Catherine McCammon[1], Artem Chanychev[1], Tomoo Katsura[1], Michael Hanfland[3], Aleksandr Chumakov[3] (1.Bayerisches Geoinstitut, Universitat Bayreuth, Bayreuth, Germany, 2.Jilin University, Changchun, China , 3.European Synchrotron Radiation Facility (ESRF), Grenoble Cedex, France.)

Reactive Melt Channelization in the Earth's Mantle

*Matej Pec[1], Benjamin Holtzman[3], Mark Zimmerman[2], David Kohlstedt[2]

1. Massachusetts Institute of Technology, 2. University of Minnesota, 3. Lamont-Doherty Earth Oservatory, Columbia University

The formation of oceanic plates requires extraction of large volumes of melt from the mantle. Several lines of evidence suggest that melt extraction is rapid and, therefore, necessitates high-permeability pathways. Such pathways may form as a result of melt-rock reactions.

We report the results of a series of Darcy-type experiments designed to study the development of channels due to melt-solid reactions in mantle lithologies. We sandwiched a partially molten rock between a melt source and a porous sink and annealed it at high pressure (P = 300 MPa) and high temperatures (T = 1200˚ or 1250˚C) with a controlled pressure gradient ($\partial P/\partial z$ = 0-100 MPa/mm). To study the influence of lithology on the channel formation, we synthesized partially molten rocks of harzburgitic (40:40:20 Ol –Opx –basalt), wherlitic (40:40:20 Ol –Cpx –basalt) and lherzolitic (65:25:10 Ol –Opx –Cpx) composition. The melt source was a disk of alkali basalt.

In all experiments, irrespective of the exact mineralogy, melt - undersaturated in silica - from the source dissolved pyroxene in the partially molten rock and precipitated olivine (~Fo_{82}), thereby forming a dunite reaction layer at the interface between the source and the partially molten rock. In samples annealed under a small pressure gradient, the reaction layer was roughly planar. However, if the velocity of melt due to porous flow exceeded ~0.1 μm/s, the reaction layer locally protruded into the partially molten rock forming finger-like, melt-rich channels in rocks of wherlitic and harzburgitic composition. The lherzolitic rocks were generally impermeable to the melt except at highest pressure gradients where a narrow fracture developed, forming a dyke which drained the melt reservoir. Three-dimensional reconstructions using micro-CT images revealed clear differences between the dyke (narrow, through-going planar feature) and the channels formed by reactive infiltration (multiple sinuous finger-like features). Apparently, the fraction of soluble minerals together with the melt fraction in the partially molten rock control whether dykes or reactive channels develop. Our experiments demonstrate that melt-rock reactions can lead to channelization in mantle lithologies, and the observed lithological transformations broadly agree with those observed in nature.

Keywords: melt - rock reaction, mantle, melt migration

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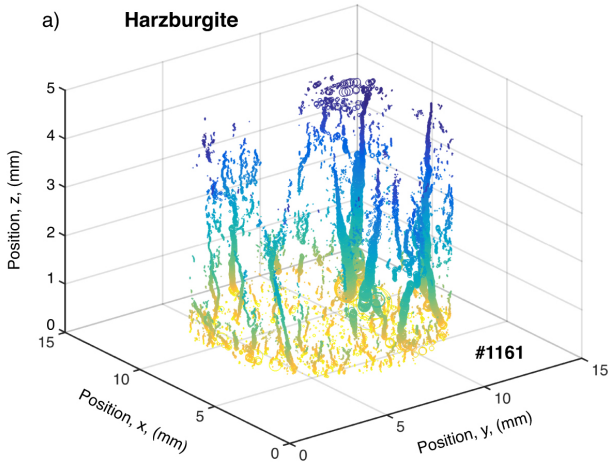

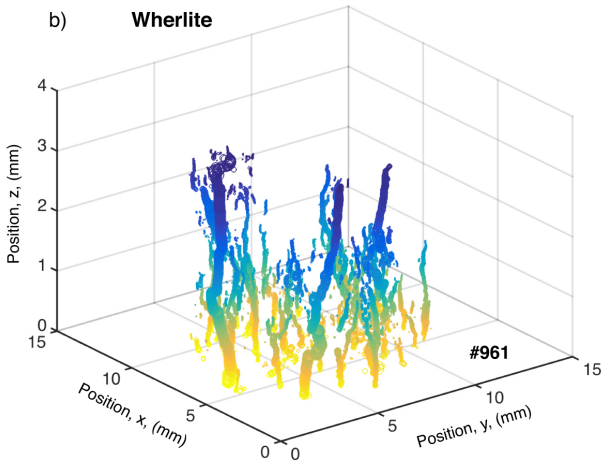

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Deep structure and origin of the intraplate volcanoes in Northeast Asia

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We have investigated the detailed mantle transition zone (MTZ) structure beneath the active Changbai intraplate volcano in NE Asia by using seismic tomography and receiver-function methods. Teleseismic receiver functions recorded at many broadband stations are obtained by using a common-conversion-point stacking method. For conducting the time-to-depth conversion, we use a 3-D velocity model of the study region so as to take into account the influence of structural heterogeneities. Our results reveal significant depth variations of the 410, 520, and 660 km discontinuities. A broad depression of the 410 km discontinuity and a low-velocity (low-V) anomaly are revealed beneath the Changbai volcano, which may reflect a large-scale hot mantle upwelling around the 410 km discontinuity with a positive Clapeyron slope. The 520 km discontinuity is identified clearly, and its uplift occurs above the stagnant Pacific slab. We also find a prominent depression of the 660 km discontinuity, which is elongated along the trend of deep earthquake clusters in a range of 39˚N–44˚N latitude, and the depression area has a lateral extent of about 400 km. Because the 520 and 660 km discontinuities correspond to positive and negative Clapeyron slopes, respectively, we think that the 520 uplift and the 660 depression are caused by the cold subducting Pacific slab. A part of the Pacific slab may have penetrated into the lower mantle and so caused the large-scale 660 depression in front of the deep earthquake clusters. Our results also reveal a part of the upper boundary of the subducting Pacific slab in the MTZ.

High-resolution P-wave velocity (Vp) tomography of the upper mantle beneath NE China is obtained by inverting teleseismic P-wave travel-time data recorded by two dense linear arrays. The inclusion of the new data set has greatly improved sampling of the upper mantle beneath the study region, providing tight constraints on the seismic structure under the intraplate Wudalianchi and Halaha volcanoes. Local-scale low-Vp anomalies are revealed in the shallow mantle beneath the two volcanoes, whereas a large-scale high-Vp zone is imaged in the MTZ. These new results suggest that the two volcanoes, though located at different sites above the stagnant Pacific slab in the MTZ, are likely related to the deep subduction and dehydration of the Pacific slab, possibly through hot and wet upwelling in the big mantle wedge beneath Wudalianchi and through deeper hydrous upwelling related to slab avalanche beneath Halaha. Our results also reveal other striking features, such as high-Vp anomalies resting atop the 410-km discontinuity beneath the Great Xing'an Range and the Songliao Basin, which are attributed to detached continental lithosphere. The delamination most likely occurred in the Cretaceous, which induced widespread magmatism in NE China.

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Asian Earth Sci. 145, 349-367.

Keywords: Intraplate volcano, mantle structure, seismic tomography

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3D passive-source reverse-time migration imaging of mantle discontinuities

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With the advance of computational power and deployment of dense seismic networks, wave-equation-based imaging methods, which account for wave multi-pathing, scattering and focusing/defocusing, have become increasingly practical and advantageous for imaging complex crustal and mantle discontinuity structures. Over the past few years, we have developed a 3D passive-source reverse-time migration (3D PS-RTM) method using scattered and converted earthquake arrivals to image mantle discontinuities. Here we present results of its first applications in two different tectonic regions with different receiver settings and thus different applicable wave frequencies: The western U.S. centered on the Yellowstone and southwest Japan. Data processing involves selection of quality teleseismic events with epicentral distances of 28-98 degrees, calculation of vertical-, radial- and transverse-component receiver functions with an iterative deconvolution method, suppression of random noise using principle component analysis, and interpolation of wavefields recorded at stations onto numerical grids of the model surface. The P arrival and its coda, which contains the converted and scattered waves, are time reversed and back-propagated separately into the model via a finite-difference method. The back-propagated wavefields are decomposed into the P and S modes and their imaging condition reflects the convergence of the two modes at velocity interfaces or scatters. In the western U.S., the ~70 km station spacing of the USArray stations dictates that only intermediate- and long-period (>10 s) wavefields of teleseismic body-wave arrivals can be reliably reconstructed on the surface. Our RTM results show remarkably clear images of the 410-, 520- and 660-km discontinuities. The mantle transition zone is ~20 km thinner than the average of the transition zone beneath the western U.S. and the global average, an anomaly comparable to that beneath Iceland. The anomaly is centered ~100 km northwest of the Yellowstone hotspot in a 200 km by 300 km area, supporting the notion of a tilted mantle plume between the surface hotspot and the high temperature thermal anomaly in the transition zone. In contrast, we observe a ~40-km depression of the 660-km discontinuity, an indication of substantially lower mantle temperatures, beneath Nevada, where tomographic models reveal the presence of a subducted slab. In southwest Japan, the combined seismic stations from the Hi-net and other networks have a station spacing of 10-20 km, making it possible to reconstruct teleseismic body-wave wavefields on the surface at periods down to 2-3 s and thus achieve potentially much higher resolution than in Yellowstone. Teleseismic P waves for earthquakes with magnitude greater than 5.6 between 2004-2018 were collected from the Hi-net, F-net, JMA, and several university networks. Data processing and imaging are ongoing and preliminary results for southwest Japan will be presented at the meeting.

Keywords: passive-source reverse-time migration, mantle transition zone, receiver function, Yellowstone, Japan subduction zone, 3D wave simulation

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Configuration of slab beneath Ogasawara Islands and P-wave time differences between high and low frequencies

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Here I examine arrival time differences in P wave between high and low frequencies, and see a link with the configuration of the descending Pacific slab beneath Ogasawara Islands.

Furumura and Kennett (JGR 2005) showed that P and S waves from intraslab earthquakes beneath the Sea of Japan have low-frequency onsets followed by high-frequency long-duration signals, suggesting the result of small-scale quasi-laminar heterogeneity within the subducting Pacific slab. The late arrivals of high-frequency P and S signals are enhanced for earthquakes deeper than 400 km, probably, due to the low-velocity wedge in the slab (Furumura et al., JGR 2016). By exploring broadband seismograms of regional P waves from deep earthquakes (depth>300 km) worldwide, Ohata and Kuge (JpGU 2017) suggested a possibility of similar observations to Furumura’s in other western Pacific regions. Ohata and Kuge (JpGU 2018) showed the observations from deep earthquakes beneath Fiji and Kermadec Islands.

These previous studies indicate the presence of heterogeneity within the subducting Pacific slab that causes arrival time differences in P wave between high and low frequencies. This also suggests that time delay of high-frequency P waves can be used as a measure to find out if the P waves have traveled within a subducting slab. Based on the idea, I examined arrival time differences of P-wave peaks between high and low frequencies for deep earthquakes beneath Ogasawara Islands.

For an aftershock (USGS depth 678 km) of the isolated 2015 deep large earthquake, time differences of P-wave peaks between high and low frequencies were insignificant to the northwest and east. High-frequency P peaks from a deep earthquake in the nearby Wadati-Benioff zone were, however, delayed, compared with low-frequency ones. The Pacific slab is likely to be absent in the northwestern side of the aftershock. If the Pacific slab extends to the aftershock, its bend toward the east above the aftershock can explain the observation.

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Cool lower mantle transition zone inferred from seismic anisotropy of deformed ringwoodite

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Seismic anisotropy is a powerful tool for inferring dynamics in the Earth’ s interior and recently detected in the lower part (520-660 km depth) of the mantle transition zone (MTZ). The most plausible explanation for seismic anisotropy in the lower MTZ is crystallographic preferred orientation (CPO) of ringwoodite because ringwoodite is dominant in the region (~60 vol%) and has single-crystal anisotropy up to ~10% while the second dominant mineral (majoritic garnet, ~40 vol%) is elastically isotropic. Here we show that CPO of ringwoodite cannot account for seismic anisotropy in the lower MTZ by analyzing ringwoodite samples deformed at 17-18 GPa and 1300-1500 K with a deformation-DIA apparatus and by simulating ringwoodite deformation by viscoplastic self-consistent modeling. The deformed ringwoodite samples showed clear CPO patterns primarily attributed to dislocation glide with the 1/2<110>{111} slip system; however, calculated seismic anisotropy of the model mantle rock was less than 0.4%. To explain seismic anisotropy in the lower MTZ, akimotoite is necessary to exist in the lower MTZ, whose CPO can produce seismic anisotropy in this region. In this hypothesis, temperature in the lower MTZ should be lower than its present estimate by more than 200 K because akimotoite is stable at relatively low temperature.

Keywords: mantle transition zone, seismic anisotropy, ringwoodite, crystallographic preferred orientation, high pressure, deformation

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Crystal chemistry and compressibility of $Fe_{0.5}Mg_{0.5}Al_{0.5}Si_{0.5}O_3$ and $FeMg_{0.5}Si_{0.5}O_3$ silicate perovskites at pressures up to 95 GPa.

*Iuliia Koemets[1], Zhaodong Liu[2], Egor Gennadievich Koemets[1], Catherine McCammon[1], Artem Chanychev[1], Tomoo Katsura[1], Michael Hanfland[3], Aleksandr Chumakov[3]

1. Bayerisches Geoinstitut, Universitat Bayreuth, Bayreuth, Germany, 2. Jilin University, Changchun, China , 3. European Synchrotron Radiation Facility (ESRF), Grenoble Cedex, France.

Bridgmanite is widely considered the most abundant mineral in the Earth’ s lower mantle. Its properties control the dynamics of this region and a large number of previous studies have been focused on the behaviour of bridgmanite at mantle conditions. Bridgmanite elasticity may be affected by chemical variations, presence of oxygen vacancies, and pressure-induced high-spin to low-spin transition in iron. In the case of bridgmanite, the effect of pressure-driven spin transitions on bulk modulus is complex, because iron could occupy different crystallographic sites and can occur as both ferrous and ferric iron. In addition, high-pressure experiments with silicate perovskite end-members could provide us with a self-consistent elasticity database and clarify spin transition impact on elasticity.

We investigate crystalline materials with two compositions, $FeMg_{0.5}Si_{0.5}O_3$ and $Fe_{0.5}Mg_{0.5}Al_{0.5}Si_{0.5}O_3$, recovered after experiments in Kawai-type multi-anvil apparatus. After full sample characterization in terms of chemical composition, crystal structure, and iron oxidation state, we performed a series of compressibility experiments in diamond anvil cells up to 95 GPa. During compression, we collected single crystal X-ray diffraction patterns as well as Mössbauer spectra, which allowed us to follow up changes in crystal chemistry and Fe spin state during compression.

Our compressibility study on the Al-rich sample together with previously published data allowed us to reconstruct $FeAlO_3$ end-member compressibility. We found that $FeMg_{0.5}Si_{0.5}O_3$ has a previously unknown structure: the low-pressure phase is corundum-related type (space group *R3*), and above about 15 GPa it transforms to a new silicate double-perovskite. An outstanding feature of the silicate double perovskite structure is two individual octahedral sites; one occupied by Si only, and the other by iron and magnesium. Combining single crystal X-ray diffraction data and results of Mössbauer spectroscopy, we were able to decipher the crystal chemistry behaviour of this phase during iron spin crossover, which is detectable by both compressibility changes of individual polyhedra and variation of Mössbauer hyperfine parameters.

Keywords: silicate perovskite, single crystal X-ray diffraction , Mössbauer spectroscopy

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[E] Oral | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A09 TOKYO BAY MAKUHARI HALL

[S-IT24] Attenuation from crust to core: in situ experiments, observaions and implications

convener:Konishi Kensuke(Institute of Earth Sciences, Academia Sinica), Ikuo Katayama(Department of Earth and Planetary Systems Science, Hiroshima University), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Alexandre Schubnel(CNRS), Chairperson:Kensuke Konishi(Institute of Earth Sciences)

Most tomographic studies have been focused upon drawing maps of seismic velocity (SV) structures based on seismic data, with the ultimate goal of learning more about the structure and the composition of the mantle. Another key physical property that is accessible from seismic data is seismic attenuation (SA). Due to complications in isolating its intrinsic causes - e.g. local physical changes - and its extrinsic contributions - mainly scattering and other wave-propagation effects - SA has been underutilized. Yet, advances in waveform inversion have in association with recent enhancements of data permitted for a finer, more comprehensive determination of SA, opening the way to structural interpretations.
Difficulties in classifying and modelling the possible causes of intrinsic SA - e.g. temperature, melt, volatiles, and grain size - have also been raised. Increasingly, theoretical and experimental mineral physics have come to document the relationship between the behavior of SA and an assortment of other phenomena - most particularly, partial melt. These results can subsequently be used interpret seismological observations.
Seismic attenuation is critically implicated in structure, composition, and in fine mantle dynamics at the local, regional, and global scales. It may be used to constrain the existence of water in the transition zone; the presence of melt in various regions - for instance around subduction zones; and in the temperature field of the deep mantle - which would, in turn, help to resolve the chemical contribution to SV observed in this region.
In this session, we would like to discuss aspects of mantle attenuation, with the aim of sharing the current state of all relevant fields of study. We welcome contributions from different fields - in particular, from seismology, mineral physics, and geodynamics, as these may advance our mutual comprehension of SA and its implications; and lay the groundwork for future research and applications thereof.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SIT24-01] Anomalous Vp/Vs Ratios at Seismic Frequencies Might Evidence Highly Damaged Rocks in Subduction Zones

*Alexandre Schubnel[1], Lucas Pimienta[2], Marie Violay[2], Jérome Fortin[1], Hélène Lyon-Caean[1] (1.Laboratoire de Géologie, ENS PARIS, 2.EPFL, Switzerland)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SIT24-02] Imaging crustal seismic attenuation, central Taupo Volcanic Zone, New Zealand

*Stephen C Bannister[1], Sandra Bourguignon[1], Ted Bertrand[1], Cameron Asher[1] (1.GNS Science)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SIT24-03] New Constraints on Seismological Structures of the Oceanic Asthenosphere

★Invited Papers

*Nozomu Takeuchi[1], Hitoshi Kawakatsu[1], Hajime Shiobara[1], Takehi Isse[1], Hiroko Sugioka[2], Aki Ito[3], Hisashi Utada[1] (1.Earthquake Research Institute, University of Tokyo, 2.Kobe University, 3.JAMSTEC)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SIT24-04] Frequency effects on elastic properties of saturated porous rocks: Experimental investigations

★Invited Papers

*Jerome Fortin[1] (1.Laboratoire de Géologie, Ecole Normale Superieure - Paris)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SIT24-05] Rock anelasticity due to grain boundary premelting
★Invited Papers

*Yasuko Takei[1], Hatsuki Yamauchi[1], Akihiro Tsunoda[1] (1.Earthquake Research Institute, University of Tokyo)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SIT24-06] Experimental study of the effects of partial melting on anelasticity: toward quantitative interpretations of seismic high attenuation

*Hatsuki Yamauchi[1], Yasuko Takei[1] (1.Earthquake Research Institute, The University of Tokyo)

Anomalous Vp/Vs Ratios at Seismic Frequencies Might Evidence Highly Damaged Rocks in Subduction Zones

*Alexandre Schubnel[1], Lucas Pimienta[2], Marie Violay[2], Jérome Fortin[1], Hélène Lyon-Caean[1]

1. Laboratoire de Géologie, ENS PARIS, 2. EPFL, Switzerland

Unusually high compressional (P) to shear (S) wave velocity ratios (Vp/Vs) were measured at different subduction zones and interpreted as fluid-pressurized regions. Because no laboratory data reported such high values in isotropic rocks, mineralogical or anisotropic constrains were assumed. However, fluid-saturated rocks' Vp/Vs is a frequency-dependent property so that standard laboratory measurements cannot be directly upscaled to the field. Using a new methodology, we measured the property in the elastic regime relevant to field measurements for diverse lithologies. We obtained extreme Vp/Vs values, consistent with those reported at seismic frequency in the field. Consistently with a model, it shows that if high fluid pressure is a key factor, anomalous Vp/Vs values could evidence intense degrees of microfracturation in isotropic rocks, whichever its mineralogical content. The permeability of these regions could be larger than 10^{-16} m^2.

Keywords: VP/Vs ratio, undrained / drained deformation, fluids

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Imaging crustal seismic attenuation, central Taupo Volcanic Zone, New Zealand

*Stephen C Bannister[1], Sandra Bourguignon[1], Ted Bertrand[1], Cameron Asher[1]

1. GNS Science

Since 2009 we have deployed broadband and short-period seismometers across a 90 km by 55 km area in the central Taupo Volcanic Zone, New Zealand, encompassing part of the Okataina Volcanic Centre and the Kapenga (Ngakuru) graben, as well as more than 8 hydrothermal systems, including Rotokawa, Wairakei, Mokai, Ohaaki, Waikite, Waimangu, Rotomahana, and Rotorua. Seismic acquisition was carried out using rolling arrays occupying more than 60 sites, with an average spacing of 6-7 km.
We have now undertaken event detection and location analysis for c.900 earthquakes using the seismic data, inverting arrival times to derive 3-D volumes for Vp and Vp/Vs, and using spectral data from the best earthquakes to derive a 3-D volume for Qp (1/attenuation). Our path coverage and density is good between 2 kms and 8 kms depth, as visualised using calculated raypath density tensors, and as confirmed by synthetic modelling. We find low Qp (Qp<200) anomalies in the 3D volume have a strong association with low resistivity anomalies highlighted from magnetotelluric data collected in the same region, as well as with seismicity swarms; we link these features to partial melt and the effect of volatiles in the mid- and upper crust

Keywords: Seismic attenuation, Taupo Volcanic Zone

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New Constraints on Seismological Structures of the Oceanic Asthenosphere

*Nozomu Takeuchi[1], Hitoshi Kawakatsu[1], Hajime Shiobara[1], Takehi Isse[1], Hiroko Sugioka[2], Aki Ito[3], Hisashi Utada[1]

1. Earthquake Research Institute, University of Tokyo, 2. Kobe University, 3. JAMSTEC

The oceanic lithosphere and asthenosphere are one of the most fundamental features in the plate tectonics. Oceanic asthenosphere is characterized by lower S velocity (lower Vs) and stronger S attenuation (lower Qs), which shows sharp contrast with oceanic lithosphere. These features have been primarily constrained by lower frequency surface waves observed in higher quality land data. To reveal higher frequency features (or frequency dependency) and P structures (or relative behavior of P and S anomalies), in-situ observations on the seafloor would be critical.

In this presentation, we present our recent results on new features revealed by our BBOBS observations. We deployed BBOBSs in the northwestern Pacific (NOMan project) during 2010-2014. Long term and in-sits observations enabled us quantitative inference on the frequency dependent attenuation and Vp/Vs structures of the oceanic lithosphere-asthenosphere system (LAS). We previously analyzed higher frequency scattered waves and reported that the attenuation in the oceanic lithosphere is weak and frequency dependent, while that in the oceanic asthenosphere is strong and frequency independent (Takeuchi et al., 2017, Science). We recently analyzed longer period P body waveforms and revealed Vp/Vs of the LAS. The results show that P velocity reduction in the asthenosphere is large (~6.1%) and is comparable with S velocity reduction observed by surface waves (~7%). The results suggest that Vp/Vs is comparable between the lithosphere and the asthenosphere.

The stronger attenuation and lower velocities in the oceanic asthenosphere has been previously attributed to either of partial melt (Anderson et al. 1970), elevated water content (Hirth and Kohlstedt 1996), or reduced grain size (Jackson amd Faul 2010). Grain boundary softening by solid-state-mechanism (Takei et al. 2014) and flaws in the regular atomic packing under oxidising condition (Cline et al. 2018) are also reported by recent laboratory experiments. It is not straightforward to propose the mechanism which reconcile all of our observations, however, at the time of presentation, we plan to discuss consistency and inconsistency of each mechanism with our results.

Keywords: Earth's internal structure, plate tectonics

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Frequency effects on elastic properties of saturated porous rocks: Experimental investigations

*Jerome Fortin[1]

1. Laboratoire de Géologie, Ecole Normale Superieure - Paris

Comparing ultrasonic measurements (1 MHz) in the laboratory and seismic (100 Hz) or logging (10 kHz) measurements at the field scale is not straightforward due to the dispersion of body-wave velocities. In rocks fully saturated by a Newtonian fluid, dispersion is related to fluid flow at different scales, separating three regimes: the drained, undrained, and unrelaxed regimes.

In this work, the elastic dispersion and attenuation of different sedimentary rocks have been measured over a large frequency range. To cover the frequency range, forced oscillations (0.004 to 100 Hz) and ultrasonic (1 MHz) measurement techniques were done in a triaxial cell, at various differential pressures, on samples saturated by fluids of very different viscosity. The forced oscillations include both hydrostatic and axial oscillations to deduce the bulk and Young moduli, respectively.

For all the samples, we observe the drained–undrained transition and its consequence on the attenuation and the elastic moduli dispersion. Biot-Gassmann’s theory is found to be valid to explained the increased of the elastic moduli from the drained to the undrained regime. Some samples exhibit a second transition from the undrained to the unrelaxed regime, and is explained a squirt-flow mechanism. For this second transition, the rock microstructure, especially the crack density and the crack aspect ratio seems to be the major contributor of the magnitude of the dispersion and attenuation.

Keywords: porous rock, velocity dispersion, squirt-flow

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Rock anelasticity due to grain boundary premelting

*Yasuko Takei[1], Hatsuki Yamauchi[1], Akihiro Tsunoda[1]

1. Earthquake Research Institute, University of Tokyo

Recently, rock anelasticity has become a matter of concern because it provides a solid-state mechanism causing seismic low velocity and high attenuation in the upper mantle (e.g., asthenosphere). It overcomes the difficulty to interpret the seismological observations in a consistent manner with the geochemical constraint that melt fraction possible in the partially molten mantle is very small (< 0.1%, e.g., Stracke et al., 2006, EPSL). Experimental data obtained in our laboratory by using a rock analogue (binary eutectic system of organic polycrystals) demonstrate the existence of such solid-state mechanism. Our experimental results show that anelastic relaxation by grain boundary sliding is significantly enhanced from just below the eutectic temperature Te (> 0.9Te), probably due to the occurrence of grain boundary premelting (Yamauchi & Takei, 2016, JGR, Takei, 2017, Ann. Rev.). We will report our recent experimental and theoretical approaches to understanding the mechanical consequences and underlying physics of premelting.

Temperature dependence of viscosity η and attenuation Q^{-1} of a rock usually follows the Arrhenius law: $\eta = \eta_0 \exp(H/RT)$ and $Q^{-1} = Q^{-1}(f/f_M)$ with $f_M = f_0 \exp(-H/RT)$. Then, temperature dependence of shear wave velocity V_S is calculated as $d\ln V_S/d\ln T = [d\ln V_S/d\ln T]_{anh} - 2(H/RT)Q_S^{-1}/\pi$, where the first and second terms represent anharmonic and anelastic effects, respectively. This equation has long been used in seismology [e.g., Anderson, 1989]. The temperature dependence, $d\ln V_S/d\ln T$, estimated from this equation by using the observed seismic attenuation Q_S^{-1} is small, indicating that seismic discontinuity cannot be explained by a solid-state mechanism. However, we found that the Arrhenius law starts to break down at the onset of premelting, causing much steeper reductions in V_S and in η than the expectations from the Arrhenius law. Our results show that not only low velocity and high attenuation, but also seismic discontinuity and weak asthenosphere can be explained by premelting, without invoking melt.

In order to clarify the physical mechanism of premelting, we applied to our data the thermodynamic model of grain boundary developed for a binary eutectic system (Tang et al., 2006, Phys. Rev. Lett.). The model predicts a significant increase in grain boundary disorder from just below the eutectic temperature. Such structural transition in grain boundary explains well the breakdown of the simple Arrhenius law in the mechanical properties controlled by the grain boundary diffusivity. In the Earth sciences, occurrence of grain boundary premelting has been known for ice (pure system), but not for a rock (multi-component system). Because a binary eutectic system is the simplest case of a multi-component system, our result indicates the occurrence of premelting in the mantle.

Keywords: anelasticity, grain boundary premelting, asthenosphere

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Experimental study of the effects of partial melting on anelasticity: toward quantitative interpretations of seismic high attenuation

*Hatsuki Yamauchi[1], Yasuko Takei[1]

1. Earthquake Research Institute, The University of Tokyo

In the mantle wedges near subduction zones, seismic high attenuation $Q^{-1} > 0.01$ (or low $Q < 100$) is observed (e.g., Abers et al., 2014, G^3). Partial melting is generally considered as the main cause, but it is still difficult to interpret quantitatively how much melt exist there or how high temperature is. Although poroelastic effect of melt can be estimated theoretically (e.g., Takei, 2002, *JGR*), anelastic effect of melt is poorly understood. Recently, we experimentally captured that, when melt fraction is larger than 1%, anelastic relaxation of polycrystalline material is significantly enhanced by melt (Yamauchi and Takei, 2016, *JGR*). However, accurate measurement of the effect of melt on anelasticity is difficult, because a rapid grain growth occurs at the onset of melting, obscuring the effect of melt. In this study, we develop a new method to prepare samples suitable for the measurement of melt effect, perform the measurement, and establish a model of rock anelasticity applicable to the mantle both at subsolidus and supersolidus temperatures.

We use polycrystalline aggregates made from borneol + diphenylamine binary eutectic system (eutectic or solidus temperature T_m = 316 K) as a partially molten rock analogue. This system has an equilibrium microstructure similar to that of olivine + basalt system (Takei, 2000, *JGR*). Samples used in this study have a few wt% diphenylamine. Above T_m, all diphenylamine grains disappear into the melt phase. In Yamauchi and Takei (2016), to prevent the rapid growth of borneol grains during the mechanical tests at supersolidus temperatures, testing samples were pre-annealed at the supersolidus temperature ($T/T_m \simeq$ 1.03), cooled, and again partially molten to measure the melt effect without grain growth. In this previous experiment, quenched melt network remained even at $T/T_m < 1$. Therefore, the effect of microstructural change at $T/T_m = 1$ from dispersed diphenylamine grains to a connected melt network could not be examined. We have to improve the sample preparation method to clarify the effect of melt-network formation so that we can detect the existence/nonexistence of melt in the upper mantle by using the seismic data.

In this study, after partially melting a sample at supersolidus temperature ($T/T_m \simeq 1.03$) for grain growth, we kept the sample at just below the solidus ($T/T_m \simeq 0.99$) to promote the growth of diphenylamine grains from the quenched melt network. After 50-80 days, we successfully obtained a sample which is composed of large borneol grains and dispersed diphenylamine grains. We prepared two samples with melt fractions 4.5% and 3.7%. We will prepare an additional sample with different melt fraction. Using these samples, accurate measurements of elasticity at 1 MHz, anelasticity at 10^{2}-10^{-4} Hz, and viscosity will be performed at various temperatures from below to above the solidus temperature (T/T_m = 0.89 to 1.01). Data at $T/T_m < 1$ can be used to reproduce the subsolidus effect (due to grain-boundary premelting) captured in Yamauchi and Takei (2016). Data at $T/T_m \geqq 1$ can be used to clarify the melt effect. In the presentation, we will show these mechanical data and discuss seismological implications inferred from them.

Keywords: anelasticity, seismic high attenuation, partial melting, the effect of melt, melt network

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[E] Poster | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_17

[S-IT24] Attenuation from crust to core: in situ experiments, observaions and implications

convener:Konishi Kensuke(Institute of Earth Sciences, Academia Sinica), Ikuo Katayama(Department of Earth and Planetary Systems Science, Hiroshima University), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Alexandre Schubnel(CNRS)

Most tomographic studies have been focused upon drawing maps of seismic velocity (SV) structures based on seismic data, with the ultimate goal of learning more about the structure and the composition of the mantle. Another key physical property that is accessible from seismic data is seismic attenuation (SA). Due to complications in isolating its intrinsic causes - e.g. local physical changes - and its extrinsic contributions - mainly scattering and other wave-propagation effects - SA has been underutilized. Yet, advances in waveform inversion have in association with recent enhancements of data permitted for a finer, more comprehensive determination of SA, opening the way to structural interpretations.
Difficulties in classifying and modelling the possible causes of intrinsic SA - e.g. temperature, melt, volatiles, and grain size - have also been raised. Increasingly, theoretical and experimental mineral physics have come to document the relationship between the behavior of SA and an assortment of other phenomena - most particularly, partial melt. These results can subsequently be used interpret seismological observations.
Seismic attenuation is critically implicated in structure, composition, and in fine mantle dynamics at the local, regional, and global scales. It may be used to constrain the existence of water in the transition zone; the presence of melt in various regions - for instance around subduction zones; and in the temperature field of the deep mantle - which would, in turn, help to resolve the chemical contribution to SV observed in this region.
In this session, we would like to discuss aspects of mantle attenuation, with the aim of sharing the current state of all relevant fields of study. We welcome contributions from different fields - in particular, from seismology, mineral physics, and geodynamics, as these may advance our mutual comprehension of SA and its implications; and lay the groundwork for future research and applications thereof.

[SIT24-P01] Attenuation of seismic wave in water-saturated granite during triaxial deformation

*Ikuo Katayama[1], Keiya Yamada[1], Kanta Zaima[1] (1.Department of Earth and Planetary Systems Science, Hiroshima University)

[SIT24-P02] Waveform inversion for the radial elastic and anelastic structure of the lowermost mantle beneath Central America and the Caribbean

*Anselme F. E. Borgeaud[1,2], Frederic Deschamps[1], Kensuke Konishi[1], Kenji Kawai[2], Robert J. Geller[2] (1.Institute of Earth Sciences, Academia Sinica, 2.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo)

[SIT24-P03] 3-D elastic and anelastic structure of the lowermost mantle beneath the western Pacific from finite-frequency tomography

*Konishi Kensuke[1], Nobuaki Fuji[2], Frederic Deschamps[1] (1.Institute of Earth Sciences, Academia Sinica, 2.Institut de Physique du Globe de Paris)

[SIT24-P04] Inferring the lowermost mantle thermo-chemical structure beneath the Western Pacific with seismic attenuation and shear-wave speed anomalies

*Frederic Deschamps[1], Kensuke Konishi[1], Nobuaki Fuji[2], Laura J Cobden[3] (1.Academia Sinica, 2.Institut de Physique du Globe de Paris, 3.Utrecht University)

[SIT24-P05] Intrinsic attenuation factor Q of partially molten Fe–S–O system

*Chao Liu[1], Takashi Yoshino[1] (1.Institute for Planetary Materials, Okayama University)

[SIT24-P06] Effect of pore pressure on attenuation of seismic waves in thermally cracked granite

*Keiya Yamada[1], Kazuki Sawayama[2], Ikuo Katayama[1] (1.Hiroshima University, 2.Kyushu University)

Attenuation of seismic wave in water-saturated granite during triaxial deformation

*Ikuo Katayama[1], Keiya Yamada[1], Kanta Zaima[1]

1. Department of Earth and Planetary Systems Science, Hiroshima University

Rock microfracturing significantly affects attenuation of seismic wave as well as seismic velocity. In this study, seismic wave attenuation in fluid-saturated granite was estimated during triaxial deformation experiments, with particular attention focused on how microfracturing affects the attenuation.
Fine-grained Aji granite was used for experiments, with 40 mm long and 20 mm in diameter. Triaxial experiments were carried at a constant strain-rate of ~10^{-6} s^{-1} under confining pressure of 20 MPa and pore pressure of 10 MPa. During deformation, elastic wave was monitored by a pulse transmission method using both P and S wave transducers with a resonant frequency of 2 MHz. In the early stage of deformation, amplitudes of both P and S waves increase slightly due to closure of preexisting cracks and then decrease due to nucleation and growth of microcracks as the sample approaches failure, with agreement of changes in seismic velocity. Change in amplitude of shear wave tends to be larger than compressional wave, similar to those observed in fluid-saturated sandstone, suggesting that inter-crack fluid flow acts as a main source of energy dissipation. We use these wavelets to estimate attenuation (quality factor) using the spectral ratio method described by Toksoz et al. (1979); the results will be presented during the meeting.

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Waveform inversion for the radial elastic and anelastic structure of the lowermost mantle beneath Central America and the Caribbean

*Anselme F. E. Borgeaud[1,2], Frederic Deschamps[1], Kensuke Konishi[1], Kenji Kawai[2], Robert J. Geller[2]

1. Institute of Earth Sciences, Academia Sinica, 2. Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo

The origin of velocity anomalies in the lowermost mantle, e.g., thermal, chemical, or due to phase transition, is still debated. Intrinsic seismic attenuation (Q) strongly depends on temperature, thus could provide additional constraints on the thermal contribution to seismic anomalies in the lowermost mantle. In this study, we investigate the radial (1-D) elastic (Vs) and anelastic (Q) structure of the lowermost mantle beneath Central America and the Caribbean using waveform inversion. We use ~50 intermediate and deep focus earthquakes in South America recorded at the USArray and other small networks between 2004–2015. Waveforms are filtered between 12.5–200 s and cut ~20 s before the arrival of the direct S phase, and ~60 s after the arrival of the ScS phase. We use the S phase as a reference phase to correct for the effects of the structure near the events and receivers on the travel-time and amplitude of ScS waveforms (Konishi et al., 2017). Synthetic tests show that we can resolve the 1-D Q and Vs structures of the lowermost mantle, with some amount of tradeoff between them. In an attempt to reduce the tradeoff between the Vs and Q structure, we perform iterative inversion inferring in a first step the Vs structure only, and in a second step the Vs and Q structures simultaneously.

Keywords: Seismic attenuation, Waveform inversion, Lowermost mantle

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3-D elastic and anelastic structure of the lowermost mantle beneath the western Pacific from finite-frequency tomography

*Konishi Kensuke[1], Nobuaki Fuji[2], Frederic Deschamps[1]

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We introduce a finite-frequency tomography method as to simultaneously obtain 3-D shear velocity (V_S) and seismic attenuation (described as quality factor Q) structures using travel time and amplitude data. We apply this method to the mapping of V_S and Q structure in the lowermost mantle beneath the western Pacific, at an edge of the Pacific large low shear velocity province (LLSVP). We used S and ScS waves of seismograms for 31 earthquakes which occurred around the region of Tonga and Fiji. Our dataset consists of the transverse components of 1341 traces obtained from the F-net Japanese seismic station network. The waveform data is rendered to a bandpass filter of a range of 12.5–200 s, corresponding to 0.005–0.08 Hz. Both shear velocity and attenuation (Q) have lower values than PREM at the center of the bottom depth range. This feature is robust per a variety of inversions in different inversion configurations. Based upon the obtained shear velocity and attenuation (Q), we also predict possible temperature anomalies in this region. Discrepancy between the temperature anomalies predicted by the two data sets suggests that shear velocity anomalies result not only from temperature anomalies but chemical anomalis. Assuming that Q-anomalies are a good proxy for temperature, and that compositional anomalies primarily consist of an excess in iron oxide and depletion, we propose a possible thermal and compositional structure for this region. Revisions to fundamental analytical software have been effected such that more varieties of waveform analysis may be performed, utilizing progressively larger datasets. The design of packages for the computation of forward propagation has been refined to greater efficiency. The purpose, for the present, is to enable the Montecarlo inversion of waveforms. We will present the current version of the software, and demonstrate preliminary attempts to perform the Montecarlo inversion.

Keywords: attenuation, lowermost mantle, waveform inversion

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Inferring the lowermost mantle thermo-chemical structure beneath the Western Pacific with seismic attenuation and shear-wave speed anomalies

*Frederic Deschamps[1], Kensuke Konishi[1], Nobuaki Fuji[2], Laura J Cobden[3]

1. Academia Sinica, 2. Institut de Physique du Globe de Paris, 3. Utrecht University

The Earth’ s deep mantle seismic structure is dominated by two large low shear-wave velocity provinces (LLSVPs) located beneath Africa and the Pacific. These structures have been observed by many studies and data sets, but their nature, purely thermal or thermo-chemical, is still debated. Due to trade-off between temperature and composition, maps of shear-wave velocity anomalies (d$\ln V_S$) alone are unable to discriminate between purely thermal and thermo-chemical hypotheses. Seismic shear-wave attenuation, measured by the quality factor Q_S, strongly depends on temperature and may bring additional information on this parameter, allowing to resolve the trade-off between temperature and composition. Here, we invert seismic waveform data jointly for radial models of d$\ln V_S$, and Q_S at two different locations beneath the Pacific, and from a depth of 2000 km down to the core-mantle boundary (CMB). At the Northern Pacific (NP) location, sampling a region around 50º N latitude and 180º E longitude, around V_S and Q_S remain close to the PREM values, representing the horizontal average mantle, throughout the investigated depth-range, with d$\ln V_S$ ~ -0.1% and Q_S ~ 300 (compared to Q_{PREM} = 312). At the Western Pacific (WP) location, sampling the western tip of the Pacific LLSVP and the Caroline plume, both V_S and Q_S are substantially lower than PREM. Importantly, d$\ln V_S$ and Q_S sharply decrease in the lowermost 500 km, from -0.6 % and 255 at 2500 km, to -2.5% and 215 close to the CMB. We then show that WP models cannot be explained by thermal anomalies alone, but require excess in iron of 3.5 to 4.5 % from the CMB up to 2600 km, and about 0.4 to 1.0 % at shallower depths. This later enrichment may be due to the entrainment of small amounts of the Pacific LLSVP material by the Caroline plume. The values of Q_S we observe give an estimate of the temperature anomalies, around 300-400 K close to the CMB, and 150 K at shallower depths. By contrast, NP models may have a purely thermal origin and can be explained by a temperature excess of about 50 K.

Keywords: Seismic waveform, Seismic attenuation, Mantle structure, LLSVP

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Intrinsic attenuation factor Q of partially molten Fe–S–O system

*Chao Liu[1], Takashi Yoshino[1]

1. Institute for Planetary Materials, Okayama University

Heterogeneous seismic structures have been found at the top of the Earth’ s inner core in terms of attenuation and velocity (Iritani et al., 2014; Souriau and Romanowicz, 1997; Tanaka, 2012). The outermost part of the inner core with approximately 30 km thickness shows low attenuation, then attenuation increases beneath this layer (Cao and Romanowicz, 2004; Ibourichene and Romanowicz, 2018; Waszek and Deuss, 2013). The positive and negative correlations between velocity and attenuation were observed from the uppermost inner core in different areas: Pacific center in the inner core has negative correlation and the rest area has positive correlation (Attanayake et al., 2014; Godwin et al., 2018). In this study, experiments on attenuation of partially molten Fe–S–O system were performed to explain the possibility that could cause seismic anomalies.

We investigated Fe-S-O system. Sulfur and oxygen are regarded as the representative light element in the Earth’ s core. Fe samples with 1, 3 and 14 wt. % S were synthesized in piston cylinder apparatus at 900° C and 1 GPa. a small amount of oxygen was included accidentally. In-situ X-ray radiographic observations were performed at the bending magnet beam line BL04B1 at SPring-8. Deformation-DIA press with a facility of cyclic loading was used. This system could produce sinusoidal displacement in a wide range of oscillation periods from 0.2 to 100 s and generating variable amplitudes (Yoshino et al., 2016). Q value characterizing intrinsic attenuation was determined by phase lag of sample strain against the reference material at 1 GPa and up to 1200°C.

The experimental results show that frequency dependence of attenuation is not remarkable except for a fine grained-sample, whereas decrease of attenuation was found at 1100 and 920°C for Fe- 1 wt. %S and Fe- 14 wt. %S samples, respectively. The attenuation drop would occur with increasing melt fraction. Experiments of Fe-14 wt. %S sample along heating and cooling paths were done to check the influence of grain growth during experiments. Data obtained from both heating and cooling paths show that abrupt change of the attenuation occurred at around 925°C. The Young’ s modulus calculated from the strain ratio of sample and reference shows strong temperature dependence. An obvious drop occurred between 900 and 980°C in association with the occurrence of partial melting. Relationship between velocity and attenuation anomalies of the Fe–S–O system shows a positive correlation when melt fraction reaches a certain value.

Partial melting could decrease Q^{-1}, which could explain the relative low attenuation on uppermost 30 km layer throughout the top of the inner core. Combing with the positive correlation between attenuation and velocity, a large amount of partial melting could occur on the uppermost 30 km layer of the rest area except the Pacific hemisphere in the inner core.

Keywords: attenuation, partially melting, Young Modulus, inner core

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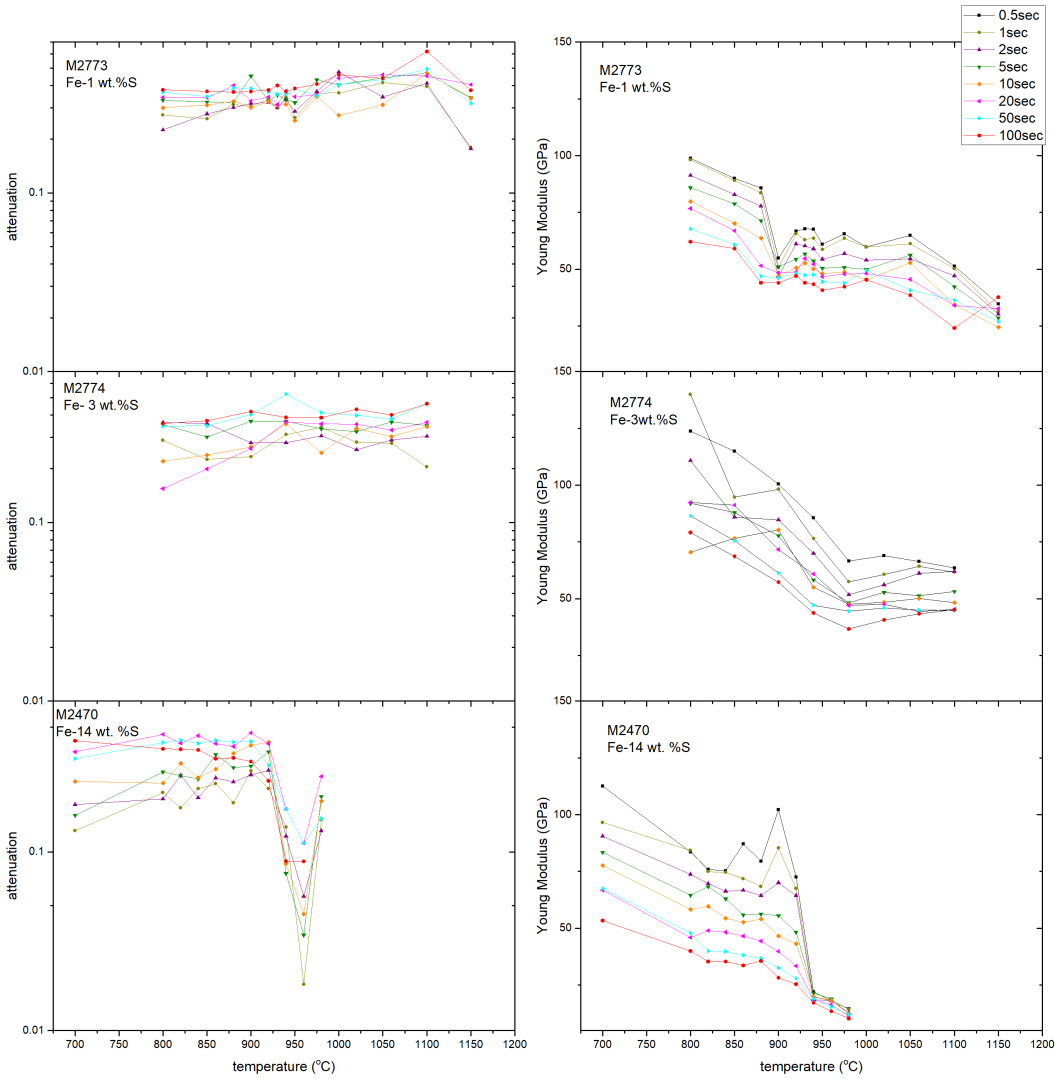

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Effect of pore pressure on attenuation of seismic waves in thermally cracked granite

*Keiya Yamada[1], Kazuki Sawayama[2], Ikuo Katayama[1]

1. Hiroshima University, 2. Kyushu University

Elastic wave attenuation is one of important physical properties to estimate the subsurface structure by geophysical explorations, and it is very sensitive to the existence of cracks and pore fluid. Especially, pore pressure is essential parameter that is closely related to geothermal fluid productions and earthquakes. To quantify pore pressure or observe its change over years may lead to the precise evaluation of the geothermal fluid reservoir and prediction of earthquakes. Therefore, it is needed to understand the quantitative relationship between elastic wave attenuation and pore pressure. Previous experimental studies have measured elastic wave attenuation, in those experiments pore pressure is constant and confining pressure is increased. However, there are few studies that measured elastic wave attenuation focusing on the change of pore pressure. In this study, We carried out hydrostatic tests using thermally cracked granite and investing the effect of pore pressure on elastic wave attenuation.
The material we used throughout this study is Aji granite. Specimens were cored from the same block and shape into cylindrical (20 mm in a diameter, 40 mm in a length). Thermal cracking was introduced by slowly heating and cooling specimens up to 200, 400, 600℃ and thereby porosity (initial 0.6%) increases to 0.8, 0.9, 2.8% respectively. Hydrostatic tests were performed under dry and wet (water fully saturated) condition, at room temperature, using intra-vessel deformation and fluid-flow apparatus at Hiroshima University. Under dry condition, confining pressure was increased to 60 MPa. Under wet condition, confining pressure remained a constant value of 60 MPa and pore pressure was decreased from 50 MPa to the atmosphere. Elastic wave was measured by the pulse transmission method and transducers were glued to both sides of specimens. We calculated elastic wave velocity (Vp, Vs) from waveforms recorded in the oscilloscope, and estimated elastic wave attenuation (Qp^{-1}, Qs^{-1}) using Fourier spectral ratio method. As a result, Vp and Vs increase with confining pressure under dry condition whereas they decrease with increasing pore pressure under wet condition. In terms of the attenuation, $Qp^{-1}$and Qs^{-1}decrease as confining pressure increases under dry condition while they increase with pore pressure under wet condition. As confining pressure is increased, attenuation by friction decreased due to the closing and locking of crack contacts. In the experiment of specimen which was heated to 600℃, $Qp^{-1}$is much smaller than Qs^{-1}under wet condition, and the trend is differ from that under dry condition. Under wet condition, attenuation by fluid flow must have a greater effect on Qs^{-1}than Qp^{-1}. Our results indicate that the response to pore pressure is different between velocity and attenuation: as pore pressure increases, Vp/Vs increases but Qp^{-1}/Qs^{-1}decreased. Because attenuation changes more greatly than velocity and is more sensitive to the change of pore pressure, elastic wave attenuation could be useful to observe the change of pore pressure under the ground.

Keywords: Elastic wave attenuation, Pore pressure, Elastic wave velocity, Aji granite, Thermal cracking

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[E] Poster | S (Solid Earth Sciences)：S-IT Science of the Earth's Interior & Techtonophysics

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_30

[S-IT24] Attenuation from crust to core: in situ experiments, observaions and implications

convener:Konishi Kensuke(Institute of Earth Sciences, Academia Sinica), Ikuo Katayama(Department of Earth and Planetary Systems Science, Hiroshima University), Takashi Yoshino(Institute for Planetary Materials, Okayama University), Alexandre Schubnel(CNRS)

Most tomographic studies have been focused upon drawing maps of seismic velocity (SV) structures based on seismic data, with the ultimate goal of learning more about the structure and the composition of the mantle. Another key physical property that is accessible from seismic data is seismic attenuation (SA). Due to complications in isolating its intrinsic causes - e.g. local physical changes - and its extrinsic contributions - mainly scattering and other wave-propagation effects - SA has been underutilized. Yet, advances in waveform inversion have in association with recent enhancements of data permitted for a finer, more comprehensive determination of SA, opening the way to structural interpretations.
Difficulties in classifying and modelling the possible causes of intrinsic SA - e.g. temperature, melt, volatiles, and grain size - have also been raised. Increasingly, theoretical and experimental mineral physics have come to document the relationship between the behavior of SA and an assortment of other phenomena - most particularly, partial melt. These results can subsequently be used interpret seismological observations.
Seismic attenuation is critically implicated in structure, composition, and in fine mantle dynamics at the local, regional, and global scales. It may be used to constrain the existence of water in the transition zone; the presence of melt in various regions - for instance around subduction zones; and in the temperature field of the deep mantle - which would, in turn, help to resolve the chemical contribution to SV observed in this region.
In this session, we would like to discuss aspects of mantle attenuation, with the aim of sharing the current state of all relevant fields of study. We welcome contributions from different fields - in particular, from seismology, mineral physics, and geodynamics, as these may advance our mutual comprehension of SA and its implications; and lay the groundwork for future research and applications thereof.

[SIT24-P01] Attenuation of seismic wave in water-saturated granite during triaxial deformation

*Ikuo Katayama[1], Keiya Yamada[1], Kanta Zaima[1] (1.Department of Earth and Planetary Systems Science, Hiroshima University)

[SIT24-P02] Waveform inversion for the radial elastic and anelastic structure of the lowermost mantle beneath Central America and the Caribbean

*Anselme F. E. Borgeaud[1,2], Frederic Deschamps[1], Kensuke Konishi[1], Kenji Kawai[2], Robert J. Geller[2] (1.Institute of Earth Sciences, Academia Sinica, 2.Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo)

[SIT24-P03] 3-D elastic and anelastic structure of the lowermost mantle beneath the western Pacific from finite-frequency tomography

*Konishi Kensuke[1], Nobuaki Fuji[2], Frederic Deschamps[1] (1.Institute of Earth Sciences, Academia Sinica, 2.Institut de Physique du Globe de Paris)

[SIT24-P04] Inferring the lowermost mantle thermo-chemical structure beneath the Western Pacific with seismic attenuation and shear-wave speed anomalies

*Frederic Deschamps[1], Kensuke Konishi[1], Nobuaki Fuji[2], Laura J Cobden[3] (1.Academia Sinica, 2.Institut de Physique du Globe de Paris, 3.Utrecht University)

[SIT24-P05] Intrinsic attenuation factor Q of partially molten Fe–S–O system

*Chao Liu[1], Takashi Yoshino[1] (1.Institute for Planetary Materials, Okayama University)

[SIT24-P06] Effect of pore pressure on attenuation of seismic waves in thermally cracked granite

*Keiya Yamada[1], Kazuki Sawayama[2], Ikuo Katayama[1] (1.Hiroshima University, 2.Kyushu University)

Attenuation of seismic wave in water-saturated granite during triaxial deformation

*Ikuo Katayama[1], Keiya Yamada[1], Kanta Zaima[1]

1. Department of Earth and Planetary Systems Science, Hiroshima University

Rock microfracturing significantly affects attenuation of seismic wave as well as seismic velocity. In this study, seismic wave attenuation in fluid-saturated granite was estimated during triaxial deformation experiments, with particular attention focused on how microfracturing affects the attenuation.
Fine-grained Aji granite was used for experiments, with 40 mm long and 20 mm in diameter. Triaxial experiments were carried at a constant strain-rate of ~10^{-6} s^{-1} under confining pressure of 20 MPa and pore pressure of 10 MPa. During deformation, elastic wave was monitored by a pulse transmission method using both P and S wave transducers with a resonant frequency of 2 MHz. In the early stage of deformation, amplitudes of both P and S waves increase slightly due to closure of preexisting cracks and then decrease due to nucleation and growth of microcracks as the sample approaches failure, with agreement of changes in seismic velocity. Change in amplitude of shear wave tends to be larger than compressional wave, similar to those observed in fluid-saturated sandstone, suggesting that inter-crack fluid flow acts as a main source of energy dissipation. We use these wavelets to estimate attenuation (quality factor) using the spectral ratio method described by Toksoz et al. (1979); the results will be presented during the meeting.

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Waveform inversion for the radial elastic and anelastic structure of the lowermost mantle beneath Central America and the Caribbean

*Anselme F. E. Borgeaud[1,2], Frederic Deschamps[1], Kensuke Konishi[1], Kenji Kawai[2], Robert J. Geller[2]

1. Institute of Earth Sciences, Academia Sinica, 2. Department of Earth and Planetary Science, Graduate School of Science, University of Tokyo

The origin of velocity anomalies in the lowermost mantle, e.g., thermal, chemical, or due to phase transition, is still debated. Intrinsic seismic attenuation (Q) strongly depends on temperature, thus could provide additional constraints on the thermal contribution to seismic anomalies in the lowermost mantle. In this study, we investigate the radial (1-D) elastic (Vs) and anelastic (Q) structure of the lowermost mantle beneath Central America and the Caribbean using waveform inversion. We use ~50 intermediate and deep focus earthquakes in South America recorded at the USArray and other small networks between 2004–2015. Waveforms are filtered between 12.5–200 s and cut ~20 s before the arrival of the direct S phase, and ~60 s after the arrival of the ScS phase. We use the S phase as a reference phase to correct for the effects of the structure near the events and receivers on the travel-time and amplitude of ScS waveforms (Konishi et al., 2017). Synthetic tests show that we can resolve the 1-D Q and Vs structures of the lowermost mantle, with some amount of tradeoff between them. In an attempt to reduce the tradeoff between the Vs and Q structure, we perform iterative inversion inferring in a first step the Vs structure only, and in a second step the Vs and Q structures simultaneously.

Keywords: Seismic attenuation, Waveform inversion, Lowermost mantle

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3-D elastic and anelastic structure of the lowermost mantle beneath the western Pacific from finite-frequency tomography

*Konishi Kensuke[1], Nobuaki Fuji[2], Frederic Deschamps[1]

1. Institute of Earth Sciences, Academia Sinica, 2. Institut de Physique du Globe de Paris

We introduce a finite-frequency tomography method as to simultaneously obtain 3-D shear velocity (V_S) and seismic attenuation (described as quality factor Q) structures using travel time and amplitude data. We apply this method to the mapping of V_S and Q structure in the lowermost mantle beneath the western Pacific, at an edge of the Pacific large low shear velocity province (LLSVP). We used S and ScS waves of seismograms for 31 earthquakes which occurred around the region of Tonga and Fiji. Our dataset consists of the transverse components of 1341 traces obtained from the F-net Japanese seismic station network. The waveform data is rendered to a bandpass filter of a range of 12.5–200 s, corresponding to 0.005–0.08 Hz. Both shear velocity and attenuation (Q) have lower values than PREM at the center of the bottom depth range. This feature is robust per a variety of inversions in different inversion configurations. Based upon the obtained shear velocity and attenuation (Q), we also predict possible temperature anomalies in this region. Discrepancy between the temperature anomalies predicted by the two data sets suggests that shear velocity anomalies result not only from temperature anomalies but chemical anomalis. Assuming that Q-anomalies are a good proxy for temperature, and that compositional anomalies primarily consist of an excess in iron oxide and depletion, we propose a possible thermal and compositional structure for this region. Revisions to fundamental analytical software have been effected such that more varieties of waveform analysis may be performed, utilizing progressively larger datasets. The design of packages for the computation of forward propagation has been refined to greater efficiency. The purpose, for the present, is to enable the Montecarlo inversion of waveforms. We will present the current version of the software, and demonstrate preliminary attempts to perform the Montecarlo inversion.

Keywords: attenuation, lowermost mantle, waveform inversion

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Inferring the lowermost mantle thermo-chemical structure beneath the Western Pacific with seismic attenuation and shear-wave speed anomalies

*Frederic Deschamps[1], Kensuke Konishi[1], Nobuaki Fuji[2], Laura J Cobden[3]

1. Academia Sinica, 2. Institut de Physique du Globe de Paris, 3. Utrecht University

The Earth’ s deep mantle seismic structure is dominated by two large low shear-wave velocity provinces (LLSVPs) located beneath Africa and the Pacific. These structures have been observed by many studies and data sets, but their nature, purely thermal or thermo-chemical, is still debated. Due to trade-off between temperature and composition, maps of shear-wave velocity anomalies (d$\ln V_S$) alone are unable to discriminate between purely thermal and thermo-chemical hypotheses. Seismic shear-wave attenuation, measured by the quality factor Q_S, strongly depends on temperature and may bring additional information on this parameter, allowing to resolve the trade-off between temperature and composition. Here, we invert seismic waveform data jointly for radial models of d$\ln V_S$, and Q_S at two different locations beneath the Pacific, and from a depth of 2000 km down to the core-mantle boundary (CMB). At the Northern Pacific (NP) location, sampling a region around 50º N latitude and 180º E longitude, around V_S and Q_S remain close to the PREM values, representing the horizontal average mantle, throughout the investigated depth-range, with d$\ln V_S$ ~ -0.1% and Q_S ~ 300 (compared to Q_{PREM} = 312). At the Western Pacific (WP) location, sampling the western tip of the Pacific LLSVP and the Caroline plume, both V_S and Q_S are substantially lower than PREM. Importantly, d$\ln V_S$ and Q_S sharply decrease in the lowermost 500 km, from -0.6 % and 255 at 2500 km, to -2.5% and 215 close to the CMB. We then show that WP models cannot be explained by thermal anomalies alone, but require excess in iron of 3.5 to 4.5 % from the CMB up to 2600 km, and about 0.4 to 1.0 % at shallower depths. This later enrichment may be due to the entrainment of small amounts of the Pacific LLSVP material by the Caroline plume. The values of Q_S we observe give an estimate of the temperature anomalies, around 300-400 K close to the CMB, and 150 K at shallower depths. By contrast, NP models may have a purely thermal origin and can be explained by a temperature excess of about 50 K.

Keywords: Seismic waveform, Seismic attenuation, Mantle structure, LLSVP

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Intrinsic attenuation factor Q of partially molten Fe–S–O system

*Chao Liu[1], Takashi Yoshino[1]

1. Institute for Planetary Materials, Okayama University

Heterogeneous seismic structures have been found at the top of the Earth’ s inner core in terms of attenuation and velocity (Iritani et al., 2014; Souriau and Romanowicz, 1997; Tanaka, 2012). The outermost part of the inner core with approximately 30 km thickness shows low attenuation, then attenuation increases beneath this layer (Cao and Romanowicz, 2004; Ibourichene and Romanowicz, 2018; Waszek and Deuss, 2013). The positive and negative correlations between velocity and attenuation were observed from the uppermost inner core in different areas: Pacific center in the inner core has negative correlation and the rest area has positive correlation (Attanayake et al., 2014; Godwin et al., 2018). In this study, experiments on attenuation of partially molten Fe–S–O system were performed to explain the possibility that could cause seismic anomalies.

We investigated Fe-S-O system. Sulfur and oxygen are regarded as the representative light element in the Earth’ s core. Fe samples with 1, 3 and 14 wt. % S were synthesized in piston cylinder apparatus at 900° C and 1 GPa. a small amount of oxygen was included accidentally. In-situ X-ray radiographic observations were performed at the bending magnet beam line BL04B1 at SPring-8. Deformation-DIA press with a facility of cyclic loading was used. This system could produce sinusoidal displacement in a wide range of oscillation periods from 0.2 to 100 s and generating variable amplitudes (Yoshino et al., 2016). Q value characterizing intrinsic attenuation was determined by phase lag of sample strain against the reference material at 1 GPa and up to 1200°C.

The experimental results show that frequency dependence of attenuation is not remarkable except for a fine grained-sample, whereas decrease of attenuation was found at 1100 and 920°C for Fe- 1 wt. %S and Fe- 14 wt. %S samples, respectively. The attenuation drop would occur with increasing melt fraction. Experiments of Fe-14 wt. %S sample along heating and cooling paths were done to check the influence of grain growth during experiments. Data obtained from both heating and cooling paths show that abrupt change of the attenuation occurred at around 925°C. The Young’ s modulus calculated from the strain ratio of sample and reference shows strong temperature dependence. An obvious drop occurred between 900 and 980°C in association with the occurrence of partial melting. Relationship between velocity and attenuation anomalies of the Fe–S–O system shows a positive correlation when melt fraction reaches a certain value.

Partial melting could decrease Q^{-1}, which could explain the relative low attenuation on uppermost 30 km layer throughout the top of the inner core. Combing with the positive correlation between attenuation and velocity, a large amount of partial melting could occur on the uppermost 30 km layer of the rest area except the Pacific hemisphere in the inner core.

Keywords: attenuation, partially melting, Young Modulus, inner core

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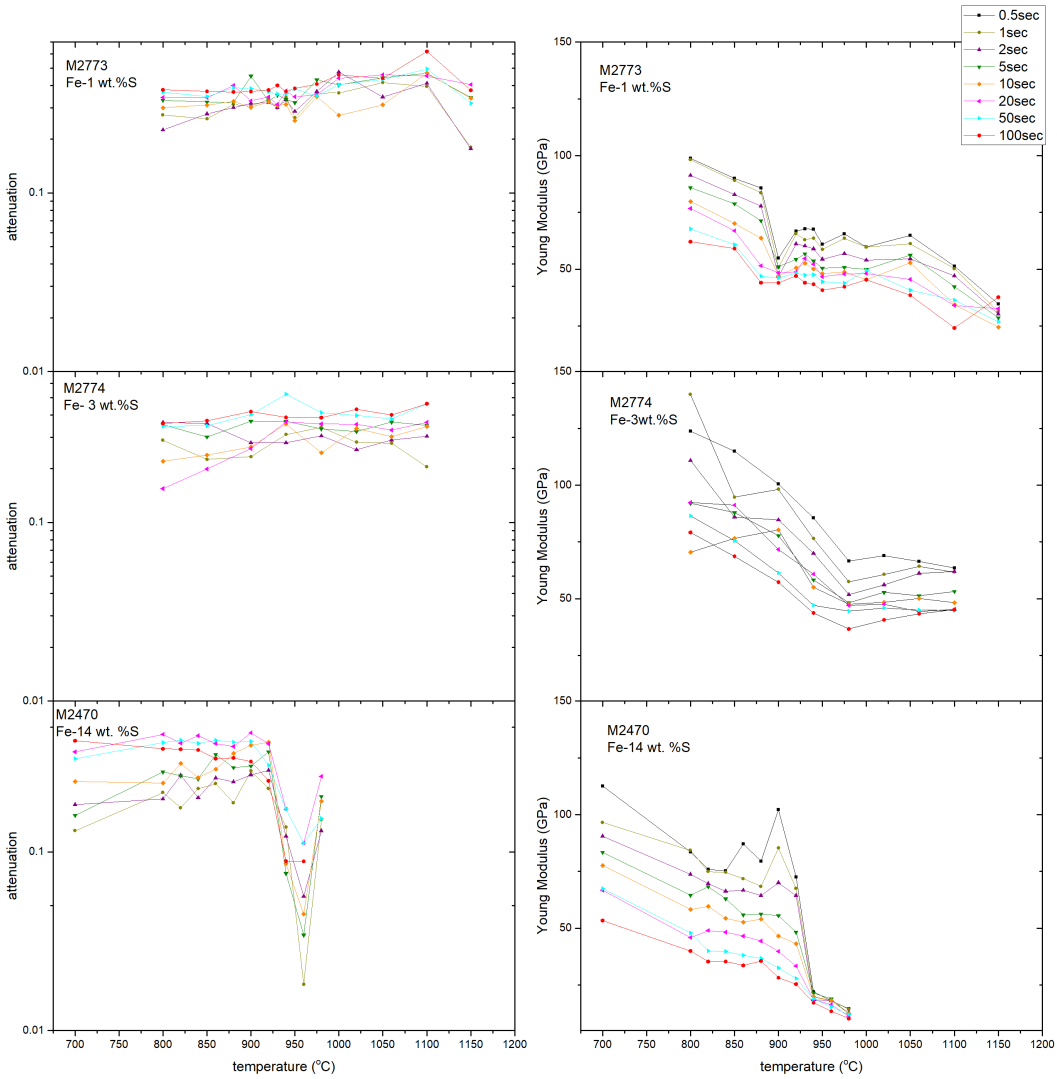

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Effect of pore pressure on attenuation of seismic waves in thermally cracked granite

*Keiya Yamada[1], Kazuki Sawayama[2], Ikuo Katayama[1]

1. Hiroshima University, 2. Kyushu University

Elastic wave attenuation is one of important physical properties to estimate the subsurface structure by geophysical explorations, and it is very sensitive to the existence of cracks and pore fluid. Especially, pore pressure is essential parameter that is closely related to geothermal fluid productions and earthquakes. To quantify pore pressure or observe its change over years may lead to the precise evaluation of the geothermal fluid reservoir and prediction of earthquakes. Therefore, it is needed to understand the quantitative relationship between elastic wave attenuation and pore pressure. Previous experimental studies have measured elastic wave attenuation, in those experiments pore pressure is constant and confining pressure is increased. However, there are few studies that measured elastic wave attenuation focusing on the change of pore pressure. In this study, We carried out hydrostatic tests using thermally cracked granite and investing the effect of pore pressure on elastic wave attenuation.
The material we used throughout this study is Aji granite. Specimens were cored from the same block and shape into cylindrical (20 mm in a diameter, 40 mm in a length). Thermal cracking was introduced by slowly heating and cooling specimens up to 200, 400, 600℃ and thereby porosity (initial 0.6%) increases to 0.8, 0.9, 2.8% respectively. Hydrostatic tests were performed under dry and wet (water fully saturated) condition, at room temperature, using intra-vessel deformation and fluid-flow apparatus at Hiroshima University. Under dry condition, confining pressure was increased to 60 MPa. Under wet condition, confining pressure remained a constant value of 60 MPa and pore pressure was decreased from 50 MPa to the atmosphere. Elastic wave was measured by the pulse transmission method and transducers were glued to both sides of specimens. We calculated elastic wave velocity (Vp, Vs) from waveforms recorded in the oscilloscope, and estimated elastic wave attenuation (Qp^{-1}, Qs^{-1}) using Fourier spectral ratio method. As a result, Vp and Vs increase with confining pressure under dry condition whereas they decrease with increasing pore pressure under wet condition. In terms of the attenuation, $Qp^{-1}$and Qs^{-1}decrease as confining pressure increases under dry condition while they increase with pore pressure under wet condition. As confining pressure is increased, attenuation by friction decreased due to the closing and locking of crack contacts. In the experiment of specimen which was heated to 600℃, $Qp^{-1}$is much smaller than Qs^{-1}under wet condition, and the trend is differ from that under dry condition. Under wet condition, attenuation by fluid flow must have a greater effect on Qs^{-1}than Qp^{-1}. Our results indicate that the response to pore pressure is different between velocity and attenuation: as pore pressure increases, Vp/Vs increases but Qp^{-1}/Qs^{-1}decreased. Because attenuation changes more greatly than velocity and is more sensitive to the change of pore pressure, elastic wave attenuation could be useful to observe the change of pore pressure under the ground.

Keywords: Elastic wave attenuation, Pore pressure, Elastic wave velocity, Aji granite, Thermal cracking

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:Daisuke Miura, Nobuo Geshi(GSJ/AIST)

This session focuses on generation and accumulation processes of magmas, magma-crust interaction and degassing, and modes of eruption, long-term forecast of eruption, dispersal and emplacement of the volcanic products. The discussion spans petrological, geochemical, geophysical, and geological processes related with volcanic activity and products in the past, the present and the future.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SVC36-01] The entire magmatic history of the Toba Caldera Complex that influenced human evolution, northern Sumatra, inferred from zircon U-Pb geochronology

*Hisatoshi Ito[1] (1.Central Research Institute of Electric Power Industry)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SVC36-02] Pre-eruptive magmatic processes of "Hakone Tokyo Pumice eruption"

*Ryo Tsujihara[1,2], Tetsu Kogiso[1], Takashi Sano[3], Hidemi Ishibashi[4] (1.Graduate School of Human and Environmental Studies, Kyoto University, 2.Asia Air Survey Co., Ltd., 3.National Museum of Nature and Science, 4.Faculty of Science, Shizuoka University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SVC36-03] Transition of magma plumbing system deduced from the melt inclusions contained in tephra minerals originated from Aso central cones.

*ryota nagaishi[1], Toshiaki Hasenaka[2], Masayuki Torii[2], ATSUSHI YASUDA[3], Natsumi Hokanishi[3] (1.Graduate of Science and Technology, Kumamoto University, 2.Center for water cycle, marin environment and disaster management , 3.Earthquake Reserach Institute, The University of Tokyo)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SVC36-04] Pre-eruptive magma dynamics of the climactic 110ka eruption of Toya caldera, Japan

*Akihiko Tomiya[1], Yoshihiko Goto[2], Tohru Danhara[3], Shanaka L de Silva[4] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 2.Muroran Institute of Technology, 3.Kyoto Fission-Track Co., Ltd., 4.Oregon State University, College of Earth, Ocean and Atmospheric Sciences)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SVC36-05] Voluminous silicic magma formation for the 30 ka Aira catastrophic caldera-forming eruption: contributions of crust-derived mafic and felsic magmas

*Ayumu Nishihara[1], Yoshiyuki Tatsumi[2,1], Keiko Suzuki-Kamata[2,1], Katsuya Kaneko[1,2], Jun-Ichi Kimura[3], Qing Chang[3], Hironobu Hinata[4], Takashi Miyazaki[3], Bogdan Stefanov Vaglarov[3] (1.Department of Planetology, Graduate School of Science , Kobe University, 2.Kobe Ocean-Bottom Exploration Center, 3.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology, 4.Kobe Municipal Tarumi Junior High School)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SVC36-06] Stratigraphy and petrological relations of pre-Aso volcanic rocks in Tateno district, Minami-Aso village

*Shota Togawa[1], Toshiaki Hasenaka[2], Masayuki Torii[2], Yasushi Mori[3] (1.Graduate school of science and technology, 2.Center for Water Cycle, Marine Environment and Disaster management, Kumamoto University, 3.Kitakyushu Museum of Natural History and Human History)

The entire magmatic history of the Toba Caldera Complex that influenced human evolution, northern Sumatra, inferred from zircon U-Pb geochronology

*Hisatoshi Ito[1]

1. Central Research Institute of Electric Power Industry

The entire magmatic history of the Toba Caldera Complex (TCC), which involves the climactic Youngest Toba Tuff (YTT) super-eruption at ~74 ka, was investigated using zircons from the Oldest Toba Tuff, a post-caldera lava dome and detrital zircons from Toba lake sediments (whitish tuffaceous fine sand) deposited after the YTT activity. It was reconfirmed by U-Pb method that magmatic activity of the TCC started at ~1.3 Ma and it was newly found that the zircon-forming magmatic activity of TCC culminated at ~0.3 Ma, well before the ~0.07 Ma YTT eruption. Therefore, the climatic YTT eruption was not triggered by intensive/rapid magma supply at the time of eruption. The trigger should have been a small magmatic input or some other mechanisms (such as mechanical roof failure and roof subsidence into the magma reservoir). The TCC magma was stored incrementally over 1 million years as cold storage and finally it vented voluminous tephras at ~0.07 Ma. The remarkable accordance of zircon U-Pb age distribution between YTT and a post YTT lava dome (Tuk Tuk lava dome) indicates that post-caldera magmatic activity/resurgence occurred using essentially the same magma with YTT.

Keywords: super-eruption, Toba Caldera, U-Pb dating

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Pre-eruptive magmatic processes of "Hakone Tokyo Pumice eruption"

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Hakone volcano is an active volcano located at the closest from the Tokyo metropolitan area, and had repeated caldera-forming eruption several times. The largest-ever eruption of Hakone volcano is the latest caldera-forming eruption that occurred at ~60 ka (VEI 6), and formed caldera structure at Gora area. This eruption started with a plinian phase, and followed by a pyroclastic flow phase. The plinian fall pumice, called Hakone Tokyo Pumice (HTP), covered all over Kanto area, and the pyroclastic flow reached about 50 km away from the eruptive center (Kasama and Yamashita, 2008). It is very important to investigate the pre-eruptive magmatic processes of this eruption, hereafter called "Hakone Tokyo Pumice eruption", in detail to evaluate the risk that an eruption of the same magnitude will occur in the future. Therefore, in this study, we clarified the pre-eruptive processes of the Hakone Tokyo Pumice eruption.

Samples were collected at Ashinoyu, Kanagawa prefecture. Pumice and scoria were found as essential clasts, and pumice with mafic enclaves was also observed. We analyzed whole-rock compositions using XRF (National Museum of Nature and Science), carried out the petrographic structure analysis using polarization microscope and SEM (Kyoto Univ.), and analyzed the major element compositions using EPMA (Kyoto Univ.).

Pumice was rhyolite from dacite (SiO_2 = 64-71 wt.%) with plagioclase, clinopyroxene, orthopyroxene, magnetite, ilmenite, apatite and olivine phenocrysts. Scoria was andesite (SiO_2 = 58-60 wt.%) with plagioclase, clinopyroxene, orthopyroxene, magnetite, apatite and olivine phenocrysts. Mafic enclaves were basalt to basaltic andesite (SiO_2 ~52 wt.%) with plagioclase, magnetite and olivine phenocrysts. The chemical compositions of the glass and phenocryst minerals suggest that four types of melts coexisted, and it is considered that there were four types of chemically different magmas in the magma chamber before the eruption. Whole rock compositions of SiO_2 > ~67 wt.% and SiO_2 < ~67 wt.% show different trends. According to the whole rock compositional trends at SiO_2 > ~ 67 wt.% and chemical zoning of plagioclase phenocrysts, it is suggested that the crystal differentiation occurred in the most silicic magma. According to the whole rock compositional trends at SiO_2 < ~ 67 wt.% and chemical zoning of plagioclase and olivine phenocrysts, it is suggested that magma mixing occurred in the magma chamber. Pre-eruptive temperature are estimated by using Fe-Ti oxides geothermometer to be 820-880 ℃. Pre-eruptive melt water content is estimated by using melt-plagioclase geothermo-hygrometers to be 4.2-7.2wt.%. These estimations indicate that the magma chamber was located at the depth of 5.5-10.5 km assuming that silicic melt was saturated with water. Timescale from the last magma mixing to the eruption was estimated to be 30 days to 1 year on the basis of the Fe-Mg diffusion modeling of an olivine phenocryst.

These observations suggest that the pre-eruptive processes of the Hakone Tokyo Pumice eruption progressed as follows: first a differentiated silicic magma existed in the magma chamber existed at depth $\geq$5.5-10.5 km, there mafic magma intruded and mixed, and the eruption began after about 30 days to 1 year from the last magma mixing.

The depth of the magma chamber at the Hakone Tokyo Pumice eruption roughly agrees with the depth of the current magma chamber estimated based on geophysical observations (~10 km: Yukutake et al.,

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2015). In order to accurately evaluate the risk of the future eruption, it is necessary to clarify the details of the pre-eruptive processes after Hakone Tokyo Pumice eruption.

Keywords: Hakone volcano, pre-eruptive magmatic process, caldera-forming eruption

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Transition of magma plumbing system deduced from the melt inclusions contained in tephra minerals originated from Aso central cones.

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Aso central cones produced basaltic to rhyolitic lavas and tephras after four gigantic pyroclastic eruptions, i.e. Aso-1, Aso-2, Aso-3, and Aso-4. Aso central cone pumice 1 ~ 6 (ACP1 ~ 6; Takada, 1989) represent voluminous volcanic products in post-caldera stage, and become key beds in Aso area. In the course of this study we found olivine-rich tephra between ACP4 and ACP3 (We call this as ACP3/4 scoria). In this study, we analyzed minerals, melt inclusions contained in tephra minerals, and volcanic glasses contained in ACP4, ACP3/4 scoria, ACP3, and ACP2 in order to compare with their result with ACP1 (Brouillet et al., 2018), Holocene scoria (Kishimadake, Ojodake, Kamikomezuka, and Nakadake) (Kawaguchi, 2018, personal communications), Aso-3 and Aso-4 (Kaneko et al., 2007, 2015), and deduce magma plumbing system of post-caldera stage of Aso volcano. The peak plagioclase composition contained in ACP4 ~ ACP1 is An# = 60~70, which is different from that of Aso-3 and Aso-4. The composition of melt inclusions in ACP2 and ACP4 does not change irrespective of host minerals and is almost the same as that of matrix glass. On the other hand, melt inclusions in ACP3/4 scoria show different compositions depending on host minerals. The composition of melt inclusions in ACP3 pyroxene is completely different from matrix glass. The maximum water content of melt inclusions in ACP4, ACP3/4 scoria, ACP2 is 1.3 wt.%, 3.8 wt.%, 3.0 wt.%, respectively. The P-T conditions of magma reservoirs of ACP2 and ACP4 are estimated as ACP2 : 890 ~ 920 ℃, 2 kbar, ACP4 : 900 ~ 920 ℃ (P = 2 kbar) from the composition of minerals and melt inclusions, and water content of melt inclusions.

Keywords: Aso volcano, Melt inclusion, FT-IR

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Pre-eruptive magma dynamics of the climactic 110ka eruption of Toya caldera, Japan

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[Introduction & Methods] Caldera-forming eruptions are among the most hazardous of natural events and need to be properly predicted. An important part of this effort is to elucidate the pre-eruptive history of the magma systems through detailed petrological studies. Toya caldera, Japan, is an ideal laboratory for this purpose because of its youth and excellent preservation. It has two post-caldera volcanoes, Nakajima and Usu, the latter of which is one of the most active volcanoes in Japan.
According to previous studies (e.g., Suzuki et al, 1970; Ikeda & Katsui, 1986; Machida et al., 1987; Feebrey, 1995; Lee, 1996; Machida & Yamagata, 1996), a catastrophic eruption occurred at ca. 110 ka, producing large-scale pyroclastic flows and a wide-spread co-ignimbrite ash (>150km^3), and the magma was mainly a homogeneous high-silica rhyolite. The eruption sequence and pre-eruptive magma processes are, however, not yet well understood because the stratigraphic units differ between different researchers and previous petrological interpretations includes some errors. Therefore, we have conducted new geological and petrological studies, including analyses of bulk-rock compositions (XRF) and volcanic glass and mineral compositions (EPMA, LA-ICP-MS). Part of the geological studies has been published by Goto et al. (2018).

[Results] We divided the eruptive product into units 1 to 6 [see Goto et al. (2018) for detail]. Unit 1 is an ash-fall deposit consisting of glass shards. Units 2, 4, 5, and 6 are pyroclastic surge and flow deposits. Unit 3 consists of base surge and ash-fall deposits. Large lithic clasts occur in unit 4 and the lower parts of units 5 and 6.
Most pumice clasts are homogeneous white pumice (SiO_2=ca.77%, K_2O=ca.2.8-3.2%; similar to the opx-HSR of Feebrey(1995)). Half of pumice clasts in unit 6 are banded and gray pumice, showing two types of chemical variations. One (hb-LSR, ibid) trends toward the Nakajima andesite, and the other (cum-HSR, ibid) toward the Usu rhyolite.
Glass and mineral compositions also have variations in unit 6. For plagioclase, we identified 3 types (A, B, and C). Type A (An=ca.12) is dominant. Type B is anorthitic (An>=90) with a sub-type B' (An=ca.80). Type C is subdivided into C1 (An=ca.20), C2 (ca.35), and C3 (ca.55). Types C2 and C3 show dissolved textures. Orthopyroxene and magnetite also have similar variations, whereas quartz is type A, clinopyroxene is type B', and both hornblende and ilmenite are types C2 and C3. Magma A, from which type-A phenocrysts derived (the same hereafter), is the high-silica rhyolite. Magma B is a mafic magma. Others are intermediate magmas. Temperatures, estimated with geothermometers by Putirka (2008) and Andersen & Lindsley (1985), are <=800 C for magma A, 800-890 C for C1, C2, C3, and B', and >=900 C for B. Trace element concentrations and zoning profiles of phenocrysts reveal that C2, C3, and B' were closely related to each other but were not in contact with A and C1 until just prior to the eruption, that B' was derived from B, and that C1 interacted with A before eruption.
Type-A phenocrysts do not show significant reverse zonings. Diffusion times estimated for magnetite are < days. On the other hand, type-B phenocrysts show significant diffusion (e.g., Mg in plagioclase), indicating hundreds of years between the injection of magma B and the eruption.

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[Inferred magma processes] The Toya eruption commenced with a phreato-Plinian eruption (unit 1), followed by a large-scale pyroclastic surge eruption (unit 2). The eruption once decreased in intensity and changed into small-scale phreatomagmatic eruptions (unit 3). Shortly after that, the caldera-collapse began (unit 4), resulted in a large-scale pyroclastic flow eruption (units 5 and 6). The caldera collapse, following the temporary decrease in intensity, was probably caused by underpressure in the magma chamber due to the evacuation of unit 2.
Just prior to the eruption, there was a large main chamber of magma A with subordinate magma pockets C1, C2, C3, B', and B. Magma A was probably produced by extraction from a crystal mush (e.g., Wolff et al., 2015). Mafic magma (B) injected hundreds of years before the eruption, remelted the mush, producing magmas C2, C3, and B'. Magma A was not disturbed by the mafic magma until just prior to the eruption. Magma mixing occurred during the eruption probably by suction due to the decrease in chamber pressure. The eruption trigger was probably not a mafic injection but an external cause, such as fault movement (e.g., Gregg et al., 2015). The compositional variation in unit 6 indicates a close relationship with Nakajima and Usu magmas, and requires a further examination.

Keywords: Toya caldera-forming eruption, ignimbrite, high-silica rhyolite, silicic magma, magma mixing, time scale

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Voluminous silicic magma formation for the 30 ka Aira catastrophic caldera-forming eruption: contributions of crust-derived mafic and felsic magmas

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Aira catastrophic caldera-forming (CCF) eruption occurred at 30 ka and discharged voluminous silicic magma with a small amount of less silicic magma. In order to understand the genesis of magmas in the Aira CCF eruption, petrological and geochemical characteristics of the juvenile clasts and plagioclase phenocrysts in them were investigated. Important petrological and geochemical features of the Aira ejecta and related rocks are described as follows:
1. Juvenile ejecta discharged by the Aira CCF eruption consist of three types of clasts; white pumice, dark pumice, and scoria clasts. Whole-rock chemical compositions of the dark pumices are less SiO_2 contents (67.5-75.7 wt.%) than those of the white pumices (74.3-77.2 wt.%). The scoria shows andesitic composition (SiO_2=59.0 wt.%).
2. In whole-rock characteristics, the SiO_2-poor juvenile clasts have higher $^{87}Sr/^{86}Sr$ (0.70856±0.00001 of the dark pumice and 0.70738±0.00001 of the scoria) than the white pumice (0.70597±0.00001).
3. An-contents of plagioclase cores in the white and dark pumices show bimodal distributions with peaks of An_{45} and An_{80}, while the scoria contains solely high-An (>An_{65}) plagioclase.
4. In plagioclase phenocrysts of the Aira juvenile clasts, Sr isotopic ratios of the high- and low-An plagioclase cores are different (0.70680±0.00117 and 0.70575±0.00040, respectively).
5. Basement rocks beneath the Aira caldera consist of Shimanto sediments and Miocene granites. These materials have much higher $^{87}Sr/^{86}Sr$ (Shimanto sediments: >0.70965; Miocene granites: >0.70885) than the Aira juvenile clasts.
6. Pre-caldera basaltic lavas, which are the most SiO_2-poor ejecta around the Aira caldera, have lower $^{87}Sr/^{86}Sr$ (0.70425-0.70469) than the Aira juvenile clasts.
The above features suggest that voluminous silicic magma bearing the white pumices in the Aira CCF eruption was produced by mixing between low-$^{87}Sr/^{86}Sr$ felsic and high-$^{87}Sr/^{86}Sr$ mafic magmas, crystallizing the low- and high-An plagioclase, respectively. The low-$^{87}Sr/^{86}Sr$ felsic magma was distinguished from both the upper crust and pre-caldera basaltic materials in $^{87}Sr/^{86}Sr$ characteristics. If the basaltic materials show the mantle signature, the low-$^{87}Sr/^{86}Sr$ felsic magma was derived from a lower crust material. The geochemical signature of the high-$^{87}Sr/^{86}Sr$ mafic magma can be explained by assimilation of high $^{87}Sr/^{86}Sr$ upper crust materials. The lowest $^{87}Sr/^{86}Sr$ recorded in the high-An plagioclase is higher than the whole-rock $^{87}Sr/^{86}Sr$ of the pre-caldera basalts, suggesting the mafic end-member magma for the Aira CCF eruption was the lower crust origin. A frequency ratio of the low- to high-An plagioclase in the white pumice proposed that the mixing ratio of the felsic and mafic magmas was estimated at a ratio of ~8:2, which is consistent with whole-rock $^{87}Sr/^{86}Sr$ variations of the white pumice. In conclusion, the crust-derived low-$^{87}Sr/^{86}Sr$ felsic and high-$^{87}Sr/^{86}Sr$ mafic magmas had contributed to the formation of voluminous magma discharged by the Aira CCF eruption.

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Keywords: Aira caldera, caldera-forming eruption, Sr isotope ratio, magma mixing, crustal assimilation

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Stratigraphy and petrological relations of pre-Aso volcanic rocks in Tateno district, Minami-Aso village

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Petrological study of pre-caldera volcanic products is important in order to understand precursory phenomena of catastrophic caldera- forming eruptions. Volcanic activity of Aso pre-caldera stage is characterized by dominant lava flows. We report the petrography and chemical compositions of Aso pre-caldera stage lavas.
At least twelve lava flows are seen in Tateno district and they have maximum layer thickness of 20 m. They are characterized by platy joints and the top of the lava. Each lava flow interposed tuff breccia and red soil. Tuff breccia is composed of red soil, lithic fragments and weathered pumice. We made columnar section of each route and confirmed the stratigraphic relation in each.
Almost samples are olivine-two pyroxene andesite (17 samples) or olivine-hornblende-two pyroxene andesite (7 samples). And we confirmed minor types, olivine-clinopyroxene andesite (1 sample) and two pyroxene potassium-rich latite (1 sample). We realized two group lava flows. Group 1 includes three samples and group 2 does two samples. Other samples do not have the correspondence because they are different from content of major elements. The result of K-Ar age is also suggested that group 2 samples are same flow unit.
Although K-Ar age of pre-Aso lavas distributed at an altitude of 665-690m are 0.66±0.34 (Ma) and 0.78± 0.19 (Ma), the result of group 2 lava located at a height of 500m are 0.45±0.04 (Ma) and 0.48±0.03 (Ma). It is suggested that the sources of each lava were different and that the younger source was located lower in altitude than the older source. In the present Tateno Valley, Akase lava (3 ka) has a relationship sticking to the lower position of the Tateno lava (5.5 ka). It has possibility that the same relation existed in the pre-caldera stage, and that the valley may have formed due to exercise of fault or the like.

Keywords: pre-caldera stage, lava flow, tuff breccia

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:Nobuo Geshi(GSJ/AIST), Daisuke Miura

This session focuses on generation and accumulation processes of magmas, magma-crust interaction and degassing, and modes of eruption, long-term forecast of eruption, dispersal and emplacement of the volcanic products. The discussion spans petrological, geochemical, geophysical, and geological processes related with volcanic activity and products in the past, the present and the future.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SVC36-07] Caldera structure delineated by airborne gravity gradiometry

*Atusi NINOMIYA[1], Hiromasa ISHIKAWA[1], Shunsuke NOGAMI[1], Yoshio NAKASATO[1] (1.Sumiko Resources Exploration and Development Co., Ltd.)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SVC36-08] The initial fine ash deposit of the Shikotsu caldera-forming eruption at ca. 45 ka

*Chiharu Tomijima[1], Daisuke MIURA[1], Shimpei Uesawa[2], Mizuho Amma-Miyasaka[3] (1.Department of Physical Science, Graduate School of Science, Osaka Prefecture University, 2.Central Research Institute of Electric Power Industry, 3.Graduate School of Sciences, Hokkaido University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SVC36-09] Characterization of the Small-volume Pyroclastic Flows from the Kuchinoerabu-jima Volcano during 2018-2019, Southwest Japan

*Ryuta FURUKAWA[1], Teruki Oikawa[1], Nobuo Geshi[1] (1.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SVC36-10] An explanation of size and position of Mt. Fuji

*Yasushi Harada[1], Miyu Takahashi[1] (1.School of Marine Science and Technology, Tokai University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SVC36-11] Arc magmatism in the northernmost part of Kamchatka caused by the aseismic subducted Bering slab

*Tatsuji Nishizawa[1], Hitomi Nakamura[2,3,4,5], Tatiana Churikova[6,7], Boris Gordeychik[6,8], Maria Pevzner[9], Osamu Ishizuka[2,10], Hikaru Iwamori[3,4,11] (1.Volcanic Fluid Research Center, School of Science, Tokyo Institute of Technology, 2.Institute of Earthquake and Volcano Geology, Geological Survey of Japan, AIST, 3.Department of Solid Earth Geochemistry, Japan Agency for Marine-Earth Science and Technology, 4.Depeartment of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology, 5.ORCeNG, Chiba Institute of Technology, 6.GZG, Abt. Geochemie, Universität Göttingen, 7.Institute of Volcanology and Seismology, Far East Branch, Russian Academy of Sciences, 8.Institute of Experimental Mineralogy, Russian Academy of Sciences, 9.Geological Institute, Russian Academy of Sciences, 10.R & D Center for Ocean Drilling Science, Japan Agency for Marine-Earth Science and Technology, 11.Earthquake Research Institute, The University of Tokyo)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SVC36-12] Redox state of magma in the deep crust beneath NE Japan arc: constraints from cumulate xenoliths from Ichinomegata Maar

*Naoya Tsushima[1], Michihiko Nakamura[1], Yasuhiro Yanagida, Takeyoshi Yoshida[1] (1.Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University)

Caldera structure delineated by airborne gravity gradiometry

*Atusi NINOMIYA[1], Hiromasa ISHIKAWA[1], Shunsuke NOGAMI[1], Yoshio NAKASATO[1]

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The airborne gravity gradiometry (e.g., JOGMEC, 2017) revealed that collapsed caldera shows a polygonal structure consisting of a combination of fractures in the direction along the caldera contour and radial fractures cutting through them. This structure is commonly found in the Quaternary calderas such as Kutcharo caldera, Teshikaga caldera, Sen-Yakeyama caldera, Sanzugawa caldera, Southern Kurikoma volcano caldera, Onikobe caldera, Hanayama caldera, Shiobara caldera, Shishimuta caldera, and Aso caldera.
Three-dimensional inversion of the airborne gravity gradiometry data enables to stereoscopically visualize the caldera structure.

Reference: JOGMEC, 2017, Report of survey on the potential of geothermal resources.

Keywords: airborne gravity gradiometry, caldera structure

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The initial fine ash deposit of the Shikotsu caldera-forming eruption at ca. 45 ka

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We have studied a thin and fine-grained ash deposit that occurs at the bottom of a massive plinian fall unit from Shikotsu caldera, southwest Hokkaido, Japan. This fine ash deposit could be a sign of the initial stage for a catastrophic caldera-forming eruption. The ash is extensively observed at the large number of outcrops for the Shikotsu plinian fall deposit. It is believed that the Shikotsu caldera-forming eruption (SCFE) took place at ca. 42–45 ka.
The lowermost part of the fall unit is divided into two units, A1 and A2. The unit A1 is a well-sorted, thin and fine-grained ash deposit, whereas the unit A2 is constituted by four layers with the alternation of ash and pumice fall deposits. The unit A1 further comprises two sub-layers: the lower layer is a thin (~4 mm thick) and very fine-grained ash layer with sheet-like carbide and the upper one is a crystal rich fine ash layer (~30 mm thick). While the total thickness of A2 is gradually decreasing as far from the source caldera, the thickness of A1 was almost constant everywhere, which extends throughout a distance up to 70 km from the source caldera.
Dry sieve analyses at 0,5 interval between -1 and +4 in ϕ scale were carried out on 8 samples of A1 deposit. The results of grain-size distribution show a bit of change between 1.26 and 2.25 in Mdϕ and between 0.38 and 0.83 in $\sigma\phi$. These changes of Md ϕ and $\sigma\phi$ correspond to distance from 11 km to 70 km, indicating that A1 is quite well sorted and homogeneous grain-sized deposit in its long-distance transportation. These findings suggest that the unit A1 is a well-sorted, widely dispersed and high temperature dilute flow deposit. It seems to be different from the normal pyroclastic surge deposits and may be resulted from a kind of critical mode of eruption just prior to the caldera-forming plinian eruption.

Keywords: Caldera, transport system, eruption dynamics

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Characterization of the Small-volume Pyroclastic Flows from the Kuchinoerabu-jima Volcano during 2018-2019, Southwest Japan

*Ryuta FURUKAWA[1], Teruki Oikawa[1], Nobuo Geshi[1]

1. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology

A small-scale pyroclastic flow which flows several hundreds meters to several kilometers is a frequent phenomenon in volcanic eruptions. However, since pyroclastic flow often appears in short period of time, there are not many reports of direct detailed observation. Such the small-scale pyroclastic flows occurred at Kuchinoerabu-jima volcano on 18 December 2018, 17 and 29 January 2019. Images by JMA monitoring camera and aerial observation allow us to analyze these pyroclastic flows in view of aerial extents, depositional feature and flow velocity.
For the pyroclastic flows occurred at Kuchinoerabu-jima volcano at 18 December 2018 and 17 January 2019, partial collapse of eruption column resulted in pyroclastic flow just after the onset of these eruptions. The pyroclastic flow on December 18, 2018 ranged from the Shin-dake Crater (center) to 1.1 km northwest, 0.9 km southwest and 0.9 km east. The pyroclastic flow had flowed downward around the crater and descended to the foot of the volcano, lobate topography along the valley was observed. There were no signs of burning nor falling down trees due to pyroclastic flow passage. The pyroclastic flow on January 17, 2019 extends 1.9 km northwest, 1.5 km southwest and 1 km(+) east side. Pyroclastic flow extent can be identified with 3 regions: area of thick accumulated pyroclastics, thinly deposited pyroclastics with abundant collapsed trees and thin pyroclatics recognized by vegetation discoloring. The second and third regions occasionally have white smoke by forest fires as the result of hot pyroclastic material. For the pyroclastic flow of January 29, 2019, it can be identified up to about 600 m to the west from the Shin-dake Crater and there is no observation on the east side of the crater. These pyroclastic flows show similar or smaller extents compared with them of the distribution of pyroclastic flows occurred in 2014 to 2015. Most of the pyroclastic flows flowed down to the west side of Shin-dake Crater. Detailed examination of pyroclastic flow deposits in the field is expected.
Analyses of volcano-monitoring camera images of the Japan Meteorological Agency may measure the flow velocity of the pyroclastic flow occurred between 2015 and 2019. The average flow velocity of the pyroclastic flow ranges of 5 - 47 m/s and mean values of about 20 - 30 m/s. The pyroclastic flow of May 29, 2015 which flowed the furthest, was the fastest and the shortest distance was January 29, 2019 is the latest. In general, the pyroclastic flow with higher speed tends to have a longer travel distance. The pyroclastic flow that occurred on May 29, 2015, December 18, 2018, January 17, 2019 occurred by partial column collapse immediately after the eruption. The pyroclastic flow on January 29, 2019 occurred by overflow from the crater suggesting different mechanisms of generation. Multiple mechanisms of generation and flowage can be help us to understand small-scale pyroclastic flows.
Acknowledgments: The Japan Meteorological Agency, Fukuoka District Meteorological Observatory, Volcano Monitoring and Warning Center and the Kagoshima Local Meteorological Observatory provided valuable images of the eruptions.

Keywords: Kuchinoerabu, pyroclastic flow, eruption

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An explanation of size and position of Mt. Fuji

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On Mt. Fuji, there are three unsolved features. First, the volume is so large (1400km^3) as typical volume of Japanese volcano is less than 100km^3 . Second, There is a big gap(200km) between the Nasu volcanic zone and Fuji volcanic zone on which the Mt. Fuji exists at northern end. Third, the Mt. Fuji is on 150km isodepth position of the Pacific Plate surface, whereas the average depth of the Nasu volcanic front is 100km. On the other hand, we created a VRML file for 3D plate boundaries, 3D volcano position with conduits, and positions of hypocenters around Japan, and we noted that there is a convex shape of the Philippine sea plate below the Mt. Fuji position. We performed a simple 3D simulation for magma conduits originated from 100km isodepth of the Pacific plate surface. Those conduits are blocked by the Philippine sea plate and deflected to the position of Mt. Fuji. Thus, we conclude that the shape of the Philippine sea plate well explains the size, position and depth of Mt. Fuji magma.

Keywords: Mt. Fuji, Philippine sea plate, 3D simulation

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Arc magmatism in the northernmost part of Kamchatka caused by the aseismic subducted Bering slab

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Marginal parts of a subducting slab and plate can play important roles in geodynamics. For example, the strength for plate boundaries affects the driving stress of the plates and especially spin motion of relatively small plate without slabs (Matsuyama and Iwamori, 2016), slab-derived fluid from subducted aseismic slab edge is distributed beyond the seismically determined edge and contributes the arc magmatism (Nakamura et al., 2018), and mantle flow around slab edge and corner flow in a mantle wedge could generate toroidal and poloidal components in the mantle convection (Yogodzinsky et al., 2001). The northwestern edge of Pacific (PAC) Plate, the largest oceanic plate on Earth, is subducting beneath Kamchatka, which forms a massive volcanic arc consisting of three subparallel volcanic belts: the Eastern Volcanic Front (EVF), the Central Kamchatka Depression (CKD) and the Sredinny Range (SR). The northwestern edge of PAC Plate has great influences on the geodynamics of Kamchatka-Aleutian junction but many parts of this region remain unexplained. Examples include arc magmatism in the north beyond the junction and inconsistency between petrological determined thermal structure of the wedge mantle and tectonically determined mantle flow direction (e.g., Yogodzinski et al., 2001; Portnyagin et al., 2005; Portnaygin and Manea, 2008).

We investigated the northern part of SR (N-SR) from N58°05’ and up to N58°38’ located north beyond the seismically determined PAC slab edge and found several the Quaternary-age fresh lava flows, young monogenetic cones and stratovolcanoes formed on the old basement rocks of plateau lavas. The N-SR lavas are classified as medium-K series basalt to andesite and show typical arc signatures with strong but variable LILE and LREE and low HFSE concentration, which indicates that fluid components have been supplied to the area where a subducted slab is not detected seismically. The fluid components could have been derived from the lower crust and/or lithospheric mantle or aseismic subducted slab (e.g., Volynets et al., 2010; Nekrylov et al., 2018). Compared with the volcanic front lavas of EVF and the Klyuchevskoy Volcanic Group located in CKD, the N-SR lavas have relatively high Nb and Ta contents. Such arc lavas with high Nb and Ta contents have also been reported from the Quaternary southern part of SR (S-SR) (e.g., Volynets et al., 2010; Nekrylov et al., 2018) and Nachikinsky and Hailula volcanoes in the northernmost part of CKD (N-CKD) (Portnyagin et al., 2005), where have the common point that an active Wadati-Benioff zone of the PAC slab is not observed underneath (Gorbatov et al., 1997).

On the other hand, we found a left-lateral strike-slip fault crossing N-SR in NW-SE direction and also found several similar faults in the south side of N-SR. These faults seem to have formed when southeastward trench retreat accompanied with slab rollback occurred due to a recent collision of the “Kronotski Arc terrain” with Kamchatka during 7 to 2 Ma, which extinguished the northern part of the older subduction zone and formed the modern subduction structure (Lander and Shaprio, 2007; Volynets

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et al., 2010). However, according to the focal mechanisms of the earthquakes that occurred at the northern continental boundary of the Bering (BER) Plate, the BER Plate rotates clockwise about the rotation pole located at 67˚N, 176˚E (Gordeev et al., 2015). This model suggests that the BER Plate is still subducting from the northern old trench and its convergence rate decreases toward the north, which is consistent with the observation that the number of young (Quaternary) volcanoes in N-SR decreases toward the north. Therefore, the subducted aseismic BER slab beneath N-SR supplied the fluid components to the mantle wedge and caused the arc magmatism in the north beyond the seismically determined PAC slab edge. Two processes can be responsible for supplying a fertile mantle component with high Nb and Ta contents to the northernmost part and backarc area of Kamchatka: 1) a toroidal flow around the northern PAC slab edge and 2) mantle flow from the NW due to the slab rollback in SE direction.

Keywords: slab edge, Pacific Plate, Kamchatka

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Redox state of magma in the deep crust beneath NE Japan arc: constraints from cumulate xenoliths from Ichinomegata Maar

*Naoya Tsushima[1], Michihiko Nakamura[1], Yasuhiro Yanagida, Takeyoshi Yoshida[1]

1. Division of Earth and Planetary Materials Science, Department of Earth Science, Graduate School of Science, Tohoku University

Significant number of previous studies suggest that arc magmas have relatively higher fO_2 than that of mid ocean ridge basalt (MORB) or oceanic island basalt. It has been a matter of debate whether the oxidized nature of subduction zone magmas is derived from the mantle source or acquired through their differentiation in the crust. Behavior of sulfide and sulfate is sensitive to and thus can be a tracer of the redox state (or oxygen fugacity, fO_2) of magmas, because the valence state of sulfur in the magma changes from -2 to +6 through oxidation. The arc's lower crust in the subduction zones has been recently attracting many attentions as a region where magmas may change their chemical compositions significantly. The Ichinomegata maar, located in the back arc of NE Japan, is known for the rare occurrence of deep-crustal xenoliths in subduction zones. A recent petrographic study revealed that mafic xenoliths are fractionated cumulates of the calc-alkaline host magmas (Yanagida et al., 2018). Those cumulates are, therefore, the best samples to investigate the differentiation conditions of arc magmas.

In this study, we found both pyrrhotite and anhydrite from the deep crustal mafic xenoliths from the Ichinomegata maar. Almost all the pyrrhotite grains occur as small rounded inclusions whereas some as relatively large irregular shaped interstitial phases. Pyrrhotite inclusions are mainly in hornblende and some inclusions are in clinopyroxene and plagioclase. Magmatic pyrrhotite shows approximately constant non-stoichiometoric compositions (Fe+Ni+Cu/S) and a trend from Ni-rich to Cu-rich metal composition. Anhydrite occurs as inclusions in plagioclase. The occurrence of anhydrite and the fO_2 calculated from the pyrrhotite non-stoichiometry show fO_2 of +1 log unit above Ni-NiO buffer, which is almost the same as the average value of arc magmas and clearly higher than that of MORB. This study shows that the oxidized nature of the magmas of the Ichinomegata-maar was already achieved in the deep crust and the shallow oxidation model should be discarded.

Keywords: Sulfide , Sulfate , Ichinomegata maar, Mafic xenoliths

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[J] Oral | S (Solid Earth Sciences)：S-VC Volcanology

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology), Chairperson:RYUTA FURUKAWA, Teruki Oikawa

This session focuses on generation and accumulation processes of magmas, magma-crust interaction and degassing, and modes of eruption, long-term forecast of eruption, dispersal and emplacement of the volcanic products. The discussion spans petrological, geochemical, geophysical, and geological processes related with volcanic activity and products in the past, the present and the future.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SVC36-13] Deformation of a rhyolite lava below the Curie temperature: the Sanukayam lava in Kouzusima Island, Japan

*Takuma Kamio[1], Kuniyuki Furukawa[2], Tatsuo Kanamaru[3], Koji Uno[1] (1.Okayama University, 2.Aichi University, 3.Nihon University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SVC36-14] Evolution of magmatic chemistry for the Asama-Maekake volcano since 10ka revealed by whole-rock chemical analysis of pumice obtained by the trenching of air-fall tephra deposits

*Masaki Takahashi[1], Maya Yasui[1], Tatsuo Kanamaru[1] (1.Department of Earth and Environmental Sciences, College of Humanities and Sciences, Nihon University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SVC36-15] Late Pleistocene–Holocene tephra ejecta in the trench log at the southern apron of Esan volcanic complex, Japan

*Daisuke MIURA[1], Ryuta FURUKAWA[2], Kenichi Arai[3] (1.Graduate School of Science, Osaka Prefecture University, 2.Institute of Earthquake and Volcano Geology, GSJ/AIST, 3.Asia Air Survey)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SVC36-16] **Transition of eruption sequence and magma plumbing system at the 1.4 ka Nakamachineshiri eruption of Me-Akandake volcano, eastern Hokkaido, Japan.**

*Kosuke Ishige[1,2], Mitsuhiro Nakagawa[1] (1.Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2.Mitsubishi Materials Corporation)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SVC36-17] Kilo-year-evolution of magma plumbing system with dominant modes of eruption at Suwanosejima volcano, Southwest Japan

*Taketo Shimano[1], ATSUSHI YASUDA[2] (1.Graduate School of Environment and Disaster Research, Tokoha University, 2.Earthquake Research Institute, University of Tokyo)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SVC36-18] Temporal variation of the magma compositions of the Miyakejima volcano during the last 2700 years

*Nobuo Geshi[1], Teruki Oikawa[1] (1.Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology)

Deformation of a rhyolite lava below the Curie temperature: the Sanukayam lava in Kouzusima Island, Japan

*Takuma Kamio[1], Kuniyuki Furukawa[2], Tatsuo Kanamaru[3], Koji Uno[1]

1. Okayama University, 2. Aichi University, 3. Nihon University

High-viscosity rhyolite lava may have a vertical lithofacies variation with more than one hundred meter thickness. Because the interior is kept warm by its thickness and the breccia on the surface during flowing, the internal fluid lava penetrates the tip (breakout) after the flow stopped Breakout of such a time difference may be developed into a disaster. Therefore, it is necessary to understand the rheological characteristics of the rhyolite lava; however, rhyolite lava eruption has few opportunities to be observed directly. In this study, we aimed to clarify the made of lava advancing during cooling by conducting a magnetic study on Kozushima sandbank lava which is thought to have been erupted several thousands of years ago.
Paleomagnetic samples were taken from 4 pumice sites (29 samples) and an obsidian site (10 samples) in the upper glassy part. In addition, crystalline rhyolite (7 samples) and obsidian overlying the clastic layer (4 samples) were sampled. We call obsidian and pumice sites as glassy part. Analysis of thermoremanent magnetization (TRM) of the inner crystalline part and obsidian overlying the clastic layer shows a single TRM component in the orthogonal diagrams. The TRM results of the 3 pumice sites and an obsidian site shows up to two sharp demarcations in remanence directions in the orthogonal diagrams. The remaining pumice site did not provide interpretable remanence magnetization component during thermal demagnetization. The glassy part is, therefore, considered to have been deformed at least two times below 580 C due to the advance of the inner part. The sampling sites located at greater altitudes show lower temperatures at which components are demarcated. Since this is interpreted as the temperature difference inside the lava, each deformation occurred simultaneously .Mode of each deflection seems to be similar among 3 pumice sites; however, this is not the case for the obsidian site. The deformation of the thick glassy part of the rhyolite lava is not completely uniformly distributed. The obsidian site overlying the clastic layer gave a single TRM component, likely due to thermal annealing associated with abundant spherulite formation in the clastic layer.

Keywords: Rhyolite lava, Obsidian, Lava deformation, Kozushima, Paleomagnetism

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Evolution of magmatic chemistry for the Asama-Maekake volcano since 10ka revealed by whole-rock chemical analysis of pumice obtained by the trenching of air-fall tephra deposits

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The high-resolution stratigraphy of pumice deposits, which were formed by the pumice eruptions of Asama-Maekake volcano, is revealed by the trenching. It is clarified that the pumice beds consist of twenty-three units from As1 to As23 and the eruptive history comprises three active stages (I (9.5 to 8.3ka), II (6.5 to 4.7ka) and III (1.8ka>)) and two dormant stages (1 (8.3 to 6.5ka) and 2 (4.7 to 1.8ka)). The major element chemistry for pumice clasts of each pumice bed are analyzed by XRF. The pumice of the active stage I and II are enriched in Al_2O_3 and depleted in CaO, suggesting that both suffered chemical weathering. The pumice clast of the active stage III with high MgO, which is free from chemical weathering, are also high in FeO* and MnO, and depleted in TiO_2, P_2O_5 and Na_2O. The pumice in the active stage I and II shows also the similar tendency. The SiO_2 contents for most pumices of As15 to As22 are less than 60wt% and mafic andesite, while those of As1 to As13 are more than 60wt% and felsic andesite to dacite. The MgO content at 58wt%SiO_2 (Mg_{58}) of pumice of each pumice bed repeats the increase and decrease with time, but it appeares to increase temporally as a whole. It means that the MgO content of mafic end -member magma fed to the magma chamber filled with felsic end-member magma changes with time, because the pumice of Asama-Maekake volcano is produced by the magma mixing between mafic end-member magma with various MgO contents and felsic end-member magma with similar SiO_2 and MgO contents.

Keywords: Asama-Maekake volcano, tephra stratigraphy, whole-rock chemistry

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Late Pleistocene–Holocene tephra ejecta in the trench log at the southern apron of Esan volcanic complex, Japan

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1. Graduate School of Science, Osaka Prefecture University, 2. Institute of Earthquake and Volcano Geology, GSJ/AIST, 3. Asia Air Survey

In the Esan volcanic complex (EVC), northern Japan, large number of phreatic ejecta are found at around the volcanic aprons, and could be threaten to the local residences due to the close proximity. Our trench excavation study has been performed at two digging sites, and 11 samples of the black paleo soils and the charcoal for ^{14}C dating have been measured there. A source explosion crater is inferred at 2.6 and 2.2 km far from the site A and B, respectively. This close proximity between the crater and trench sites indicates that the most of deposit exposed in the trench logs are the proximal facies. At least eleven and twelve units of volcaniclastic deposits are identified at the sites A and B. The first phreatic deposit in Holocene is newly identified just prior to the EsMP episode, and it had erupted in ca. 11 ka (Es-0). Holocene phreatic episodes of Es-1 and 3 can be divided into three and five subunits. The pyroclastic surge deposit in Es-1 and 3 was confirmed, suggesting that the phreatic surge also could be threaten to the local residences. The sequence of Holocene eruptions at the EVC comprises at least 13 phreatic tephra events in 10 thousand years, implying that the cyclic phreatic eruption could manifest in every thousand years. With regards to the characteristics of phreatic explosions, it is expected that grain size plot for the phreatic deposit becomes scattering. Grain size analysis in comparison with the magmatic ejecta may not be better way to discriminate the phreatic depositional process. It is also pointed out that the deposited area of phreatic ejecta is largely constrained by a regional topography. Parts of this work was financially supported by MEXT “Integrated Program for Next Generation Volcano Research and Human Resource Development.

Keywords: Esan volcanic complex, phreatic explosion, trench excavation

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Transition of eruption sequence and magma plumbing system at the 1.4 ka Nakamachineshiri eruption of Me-Akandake volcano, eastern Hokkaido, Japan.

*Kosuke Ishige[1,2], Mitsuhiro Nakagawa[1]

1. Department of Natural History Sciences, Graduate School of Science, Hokkaido University, 2. Mitsubishi Materials Corporation

Me-Akandake volcano ,which was formed on the southwest wall of the Akan caldera, is a stratovolcano group composed of 8 volcanoes (Katsui, 1951). Nakamachineshiri is the volcanic body that occured the most explosive eruption in the Me-Akandake volcano and is an active volcano with continues fumarolic activity. Among its activities, especially the eruption approximately 14,000 years ago, was called the Nakamachineshiri Crater Activity Period 1 (NC - 1), and widely distributed pyroclastic flow and pyroclastic fall deposit from foot of the volcano to a distance.
However, detailed geological studies have not been carried out sufficiently and the details of the eruption sequence are still unclear. In addition, the petrological study of magma plumbing system associated with transition of eruption style has not been carried out sufficiently. We performed a detailed geological survey in order to clarify the eruption sequence and style of NC-1. In addition, we performed petrological study and component analysis of the volcanic deposit in order to investigate the developmental process of the conduit during eruption and magma plumbing system. As a result, detailed eruption transition of NC-1 and transition of mafic magma became clear.
NC-1 eruptive deposits can divide into 4 unit (unit 1-4) by the result of geological survey. Unit 1 compose of pyroclastic surge deposit at the vicinity of the crater and compose of closs layer of pyroclastic flow deposit and pyroclastic surge deposit contained accretionary lapilli above the silty volcanic tuff layer at the foot of the volcano. The characteristics of Unit 1 are that volcanic deposit have suffered alteration and contain a large amount of rock fragments. Unit 2 consists of pyroclastic surge deposits and pyroclastic flow deposits, which are distributed from the vicinity of the crater to the foot of the volcano and far away, but pyroclastic flow deposits dominate at the foot of the mountain. The pyroclastic flow sediment characteristically contains fresh andesite lava fragments. As a result of observation of thin sections, these lava fragments were found to be welded pyroclastic rocks. Unit 3 is mainly pyroclastic fall deposit composed of pumice and scoria. In the vicinity of the crater, it thickness thickly and the pyroclastic surge sediment is sandwiched between the pyroclastic fall deposit. This unit is the NaPS pyroclastic fall deposit described by Wada et al. (1988). Unit 4 is distributed only in the vicinity of the crater, it is composed of pyroclastic surge deposits and the composition is characterized by many scoria and rock fragments. An erosion gap was observed between Unit 1 and Unit 2, and it is considered that there was a time gap.
The rocks of the ejecta of NC-1 are basaltic andesite to dacite. These rocks contain plagioclase, clinopyroxene, orthopyroxene and Ti-magnetite as phenocrysts, associated with minor amounts of olivine in some rocks. The whole-rock SiO_2 contents range from 62.5-64.7 wt.% for pumice and from 55.0-58.1 wt.% for scoria. Pumice and scoria tend to show different trends in many elements on the Harker diagram. Pumice exhibits little variation in petrological features through all the unit. In contrast, scoria is distinguishable according to unit by Sr and P_2O_5 contents.
From these results, based on the time gap, the volcanic activity can be divided into 2 stages. The transition of the eruption is as follows.
In stage 1 (: Unit 1) which is the first activity, magma rose and phreatomagmatic explosion occurred by the magma-aquifer interactions, and the crater was expanded by repeating the explosive eruption.

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After the time gap, the mafic magma rose again and stage 2 (: Unit 2,3,4) activity began. The first activity of stage 2 is predominantly pyroclastic surge due to phreatomagmatic explosion, welded pyroclastic rock formed in or near the crater in Stage 1 were destroyed by explosive eruption. Moreover, several pyroclastic surge which flowed down the foot of the volcano became pyroclastic flow. When eruption rate rapidly increased in middle of stage 2, eruption style became sub-Plinian eruption and eruption column was formed by declining interaction of magma-water. After that, the eruption rate decreased and eruption style changed to phreatomagmatic explosion.
In NC-1 eruption, it is thought that eruption style was dominated by interaction of magma-water because aquifer was developed in volcano body. Hence, it is assumed that Nakamachineshiri edifice is a tuff cone or maar formed by repeated phreatomagmatic explosion.

Keywords: Me-Akandake volcano, Nakamachineshiri, phreatomagmatic explosion, eruption sequence

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Kilo-year-evolution of magma plumbing system with dominant modes of eruption at Suwanosejima volcano, Southwest Japan

*Taketo Shimano[1], ATSUSHI YASUDA[2]

1. Graduate School of Environment and Disaster Research, Tokoha University, 2. Earthquake Research Institute, University of Tokyo

Suwanosejima volcano is one of the most active volcanoes in Japan since at least 1950’s, but its eruption history had not been established well. In addition, the petrological knowledge of magma plumbing system has been accumulated only for a few decades (Shimano and Koyaguchi, 2001; Ishibashi and Saito, 2009). Shimano et al. (2013) established a rough history of the volcano, that Otake volcano, in the central part of the island, has been active for recent 60-70 kys. The dominant eruption style of Otake volcano was effusive in the first half period until ca. 30 ka, then explosive in the later half. This explosive period can be subdivided into two stages; Plinian pumice eruption stage until around 10 ka with long dormancy for each, and scoria eruption stage with intervening continuous ash emission until now. The mechanisms of such transitions in eruption styles and intervals, and products from pumice dominant to scoria dominant stage are substantially important for understanding long-term forecast of eruption. Thus this study summarizes the petrological features of eruptive materials of this explosive period to understand the magma plumbing system. Eruptive materials of 10 ka pumice eruption, 1813 subplinian scoria, and recent ash have been investigated in terms of EPMA and FTIR to discuss the history by estimating temperature and volatile content for these eruptions. We measured chemical compositions of phenocrysts, groundmass glass, and melt inclusions by EPMA, and glass water content of melt inclusions by FTIR.

The materials of 10 ka eruption are characterized by banded pumice that shows mingling of basaltic and dacitic magmas with wide compositional variation of phenocrysts. In contrast, the 1813 product is very homogeneous basaltic andesite but it also shows some evidence of mixing among similar basaltic andesite. The products of recent activity are a little bit different but rather similar to those of the 1813 but show much lower contrast among mixed magmas. Mineral assemblages are similar for all products with phenocrysts of plagioclase, two pyroxenes, and trace amount of olivine and oxide minerals. EPMA analyses revealed multi-modal characteristics of phenocryst compositions indicating mixing of some end-member components of magmas. On the other hand, the water content of melt inclusions shows that magmas of recent activity are degassed whereas those of 10ka and the 1813 are 2-3 wt.% H2O.

This study has been supported financially by ERI JURP 2018-G-3, and partly by the project “Integrated program for next generation volcano research and human resource development.”

Keywords: Suwanosejima, magma plumbing system, melt inclusion

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Temporal variation of the magma compositions of the Miyakejima volcano during the last 2700 years

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Evolution of the magma system of the Miyakejima Volcano between the last two caldera-forming eruptions, 2.6-2.7ka Hatchodaira eruption and the 2000 AD eruption, was reconstructed based on the new dataset of radiocarbon ages. The activity of Miyakejima during this period can be divided into three magmatic stages as follows; I) from the 6th century BC to the 2nd century AD, after the formation of the Hatchodaira caldera. This stage is characterized by the decreasing of the range and absolute value of whole-rock SiO2 concentration. II) from 7th century to 14th century after the Suoana-Kazahaya eruption in the northern slope. This stage is characterized by the gradual increasing of whole-rock SiO2 concentration from less-evolved basaltic andesite (52-53 wt% SiO2) to andesite with evolved composition. III) from the 16th century to the end of the 20th century, with gradual increasing of whole-rock SiO2 concentration from less-evolved basaltic andesite (52-53 wt% SiO2) to andesite with evolved composition. Presence of relatively large fissure eruptions with less-evolved basaltic andesite suggests the injection of less-evolved magma into the shallow magma system at the beginning of these compositional stage.

The Suoana-Kazahaya eruption in the 7th century is an eccentric activity during this period. This eruption is characterized by the eruption of andesite with highly-evolved composition (SiO2= 59-63 wt%). The aphyric andesite magma erupted at the beginning of the eruption. As the progress of the eruption, anorthosite and olivine megacryst were entrained into the andesitic magma and form porphyritic lavas. The whole-rock SiO2 of these megacryst-bearing lava ranges from 49 t- 60 wt% reflecting the abundance of the crystals. The eruption of strongly-evolved magma from the lateral fissure can be fed from the isolated small magma batch, as proposed for the plumbing system of the B and C fissures of the 1986 Izu-Oshima eruption.

Keywords: volcano, eruption, magma, Miyakejima

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[J] Poster | S (Solid Earth Sciences)：S-VC Volcanology

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_18

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology)

This session focuses on generation and accumulation processes of magmas, magma-crust interaction and degassing, and modes of eruption, long-term forecast of eruption, dispersal and emplacement of the volcanic products. The discussion spans petrological, geochemical, geophysical, and geological processes related with volcanic activity and products in the past, the present and the future.

[SVC36-P01] Reinvestigation of the eruptive history of Me-akan volcano, eastern Hokkaido, using trench survey

*Eiichi Sato[1], Keiji Wada[2], Yusuke Minami[3], Yoshihiro Ishizuka[3], Mitsuhiro Nakagawa[4], Yoshiko Adachi[4] (1.Institute for Promotion of Higher Education, Kobe University, 2.Earth Science Laboratory, Hokkaido University of Education at Asahikawa, 3.Geological Survey of Japan, AIST, 4.Department of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University)

[SVC36-P02] Eruptive history at Ponmachineshiri in Meakan volcano during the last 1000 years: Implication from trench surveys

*Yusuke Minami[1], Mitsuhiro Nakagawa[2], Eiichi Sato[3], Keiji Wada[4], Yoshihiro Ishizuka[1], Yoshiko Adachi[2] (1.Geological Survey of Japan, AIST, 2.Department of Earth and Planetary Sciences, Graduate School of Science, Hokkaido University, 3.Institute for Promotion of Higher Education, Kobe University, 4.Earth Science Laboratory, Hokkaido University of Education at Asahikawa)

[SVC36-P03] Transition of magma plumbing system during the past 14 thousand years of Mashu volcano, eastern Hokkaido

*Keiji Wada[1], Eiichi Sato[2], Kyohei Sano[3], Yuya Okada[1] (1.Earth Science Laboratory, Hokkaido University of Education at Asahikawa, 2.Institute for Promotion of Higher Education, Kobe University, 3.Shirataki-Geopark)

[SVC36-P04] Eruption sequence of 7.6 ka caldera-forming eruption from Mashu-volcano eastern Hokkaido, japan

*Shibata Shohei[1], Takeshi Hasegawa[1] (1.Department of Earth Sciences, College of Science, Ibarbki University)

[SVC36-P05] Geological study of the 1000 yBP Ma-b eruption, Mashu volcano, eastern Hokkaido: Especially for the change of eruption style.

*Kenta Ueno[1], Mitsuhiro Nakagawa[1] (1.Depatment of Natural History of Sciences, Graduate School of Science, Hokkido University)

[SVC36-P06] Petrology of the caldera-forming eruption of Nigorikawa Caldera, Southwest Hokkaido, Japan

*Yasuaki Kaenda[1], Takeshi Hasegawa[1] (1.University of Ibaraki)

[SVC36-P07] Textual analyses for pumice from precursory Plinian eruption of Aira caldera forming eruption

*Miki Ogata[1], Atsushi Toramaru[2] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu

University)

[SVC36-P08] Long-term input rate of mafic magma inferred from a long-term heat balance model of silicic magma reservoir

*Shimpei Uesawa[1] (1.Central Research Institute of Electric Power Industry)

[SVC36-P09] Outgassing and Oxidation processes of viscous magmas inferred from micro-Raman and IR spectroscopy

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[SVC36-P10] Distribution of ballistic blocks during the 2014 eruption of Ontake Volcano, central Japan

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[SVC36-P11] After 2014 eruption, The volcanic crustal deformation around Mt. Ontake

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[SVC36-P12] Geological and petrological study of Kariba volcanic group: Elucidation of the volcanic history and changes of magma

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[SVC36-P13] Stratigraphy and evolutionary mechanism for the low-K tholeiitic magmas at Kotakakura volcano in the Sengan geothermal field, Northeast Japan arc

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[SVC36-P14] Pre-eruptive magmatic processes of upper part of Goshikidake pyroclastic rocks, Zao volcano

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[SVC36-P15] Geology and petrology of Futamata volcano, Nasu volcano group, NE Japan

*Shota Watanabe[1], Takeshi Hasegawa[1] (1.Ibaraki Univ.)

[SVC36-P16] Magma of the Haruna-Caldera forming eruption in view of Shirakawa pyroclastic flow deposits-

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[SVC36-P17] Magma plumbing system in the caldera-forming eruption of Haruna volcano indicated by Satomi pyroclastic flow deposit

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[SVC36-P18] Petrology of the Minamiryu-ga-banba in Hakusan Volcano

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[SVC36-P19] Tephrochronological relations of Middle-Pleistocene tephra derived from Myoko Volcanic Group and the pumice and scoria fall deposits found in Kosha Volcano, Central Japan

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[SVC36-P20] Geologic and petrologic study of the Kamo monogenetic volcanic field,Southern Kyushu,Japan

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[SVC36-P21] **Investigation on Lava Tube Caves in Manno lava flow of Mt.Fuji**

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Reinvestigation of the eruptive history of Me-akan volcano, eastern Hokkaido, using trench survey

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Me-akan volcano is an active volcano located in the Akan Volcano area in the eastern part of Hokkaido. It is located on the southwest wall of the Akan Caldera as one of the caldera volcanoes after the Akan caldera (Furebetsu, Fuppushi, O-akan, and Me-akan) grown. It is believed that the eruption activity of Me-akan volcano started from tens of thousands of years, after which it repeatedly erupted from at least eight craters and reached the present appearance.

The eruptive history of Me-akan volcano after 12000 years ago is shown by Wada et al. (1997). They presented the three pyroclastic flows (Nakamachineshiri I: about 12000 years ago, Nakamachineshiri II: about 9000 years ago, and Nakamachineshiri III: about 5000 to 6000 years ago) with the Nakamachineshiri crater. Among them, the Nakamachineshiri I, 12000 years ago, is the largest, and it has been revealed that it flowed out in all directions from the crater. The Nakamachineshiri II and III are confirmed only at the western foot of the Me-akan volcano. For several thousand years ago, the activities such as flowing out lavas and descending pyroclasts occurred in each mountain body of Ponmachineshiri, Kitayama, Nishiyama and Akanfuji. Since about 1000 years ago, eruption activity has been intermittently occurring in Ponmachineshiri.

We have been conducting a trench survey since 2018, in order to clarify the eruption history of Me-akan volcano since 12000 years ago. In 2018, we conducted a trench survey of nine points at the eastern foot of the Me-akan volcano. In this study, we carried out reinvestigation of the eruption history of Me-akan volcano using the trench survey and the ^{14}C ages, and reported the results.

In the trench survey, the pyroclastic flow deposit was confirmed at the lowest position. From the characteristics of deposit and the age value of 12000 ±40 yrBP (13991calBP-13745calBP) from the carbonized wood contained in the deposit, this pyroclastic flow deposit can be compared with Nakamachineshiri I (Wada et al., 1997). Several pyroclastic surge deposit could be confirmed on the pyroclastic flow deposit through the soil. 6410 ±30 yrBP (7420calBP-7277calBP (95.4%)) from the soil immediately under the lowest pyroclastic surge deposit, and 2710 ±20 yrBP (2855calBP-2761calBP (95.4%)) from the soil directly above the uppermost pyroclastic surge deposit. The age value of the lower pyroclastic surge deposit is comparable to Nakamachineshiri III (Wada et al., 1997). Therefore, Nakamachineshiri III may be distributed not only at the foot of western foot but also at the eastern foot as a pyroclastic surge. In addition, the Nakamachineshiri III not only occurred at about 6000 years ago, but also the possibility of having flowed out several times as a pyroclastic surge by 2800 years ago. At the top of the pyroclastic surge deposit, there were at least 13 scoria fall deposits of Akanfuji. They were sandwiched between volcanic ash soils of several mm to several cm. The age value of 2430 ±20 yrBP (2694calBP-2635calBP (16.7%), 2614calBP-2593calBP (4.7%), 2502calBP-2355calBP (74.0%)) was obtained from the soil directly beneath the lowest deposit of Akanfuji. Therefore, the activity of Akanfuji began around 2700 years ago. This result is consistent with the age of activity of Akanfuji indicated by

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Sato and Wada (2017). At the top of the deposit of Akanfuji, there were three volcanic ashes derived from the Ponmachineshiri through thin soil. The lowest volcanic ash layer (Pon-1, Minami et al., 2019) contains wide spread volcanic ash (Ma-b: about 1000 years ago) from Mashu volcano in patch shape. Therefore, the activities of Akanfuji have been completed about 1,000 years ago, and about 1,000 years ago erupted simultaneously at Ponmachineshiri and Mashu volcano.

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Keywords: Me-akan volcano, Eruption history, Trench survey

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Eruptive history at Ponmachineshiri in Meakan volcano during the last 1000 years: Implication from trench surveys

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Eruptive histories established solely by geological records around the near-vent area are always incomplete, because the preservation potential of the volcanic deposits vary according to local conditions such as altitude, climate, and geomorphology. On the contrary, the static flank of a volcano can have a high potential for preserving volcanic deposits. Undertaking an excavation survey at a static flank, therefore, is critical to observe a more complete depositional sequence of volcanic products in order to establish the eruptive history of an active volcano.

This study focuses on volcanic activities at Ponmachineshiri in Meakan volcano during the last 1000 years. At least four layers of fall deposits were observed at outcrops in the summit area and five excavation sites on the volcanic flank. In chronological order, the fall deposits consist of Pon-1, Pon-2, Pon-3, and Pon-4.

The deposit of the Pon-1 is yellowish brown to dark brown tuff breccia in the summit area (< 15 m thick) and lapilli tuff on the flank (8 cm thick). The deposit is characterized by the presence of abundant breadcrust bombs. The component analysis in the matrix of the deposit (250 –600 μm) revealed that the deposit consists of fresh scoria (50 vol.%) and altered lithic fragments (40 vol.%) with a miner amount of free crystals (10 vol. %). Lenticular or patch-like intercalation of Ma-b (ca. 10th century AD) was observed at the basal part of the deposit.

The Pon-2 deposit is 3.5m thick in the summit area and less than 4 cm on the flank. The deposit consists of scoria (50 vol.%) and altered fragments (40 vol.%) with a miner amount of free crystals (10 vol.%). The deposit shows reddish brown tuff breccia or lapilli tuff facies in the field. The radiocarbon ages of paleosol layers immediately underlying the Pon-2 are 710±20 yrBP and 670±20 yrBP and indicate that the eruption age of the Pon-2 is 13^{th}-14^{th} century AD.

The Pon-3 deposit is yellowish brown lapilli tuff consisting of abundant hydrothermally altered fragments (90 vol.%) with minor amounts of scoria (3 vol.%), gray-pumice (2 vol.%), and free crystals (5 vol.%). The thickness of the deposit is 2 m in the summit area and 6 cm on the flank. The radiocarbon age of a paleosol layer immediately underlying the Pon-2 is 380±20 yrBP, which indicates that eruption of the Pon-3 occurred at 16^{th}-17^{th} century AD.

The deposit of the Pon-4 is blueish gray lapilli tuff. The thickness of the deposit in the summit area is 0.5 m and 3 cm on the flank. The deposit is characterized by the features of containing abundant hydrothermally altered fragments (92 vol.%) with minor amounts of accidental lithic fragments (2 vol.%) and free crystals (6 vol. %). The Pon-4 deposit overlies Ko-c2 (AD1694) and Ta-a (AD1739), thus suggesting that the eruption occurred after AD1739.

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Excavation surveys at the volcanic flank revealed that at least four eruptions occurred at Ponmachineshiri in Meakan volcano during the last 1000 years: namely Pos-1 at ca. 10^{th} century AD; Pon-2 at 13^{th}-14^{th} century AD; Pon-3 at 16^{th}-17^{th} century AD; and Pon-4 after AD1739. The products of these eruptions were preserved as geological units. Thus, these eruptions were relatively large-scale eruptions compared with other historical eruptions which have been eroded already. Coexistence of hydrothermally altered materials and magmatic materials such as scoria in the Pon-1, Pon-2, and Pon-3 indicates that these deposits were sourced from phreatomagmatic eruptions. On the contrary, the absence of magmatic fragments in the Pon-4 deposit suggest that the eruption was phreatic event.

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Keywords: Meakan volcano, phreatomagmatic eruption, phreatic eruption

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Transition of magma plumbing system during the past 14 thousand years of Mashu volcano, eastern Hokkaido

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Mashu volcano is characterized by repeated explosive eruptions during 35 thousand years, and formed a caldera (6 x 7 km diameter) by successive plinian eruptions and following a large-scale pyroclastic flows at about 7500 years ago (Katsui et al., 1975;1986; Sumita, 1990; Hasegawa et al., 2009; Kishimoto et al., 2009). This study focus on the transition of the magma plumbing system during the past 14 thousand years from caldera formation stage to post-caldera stage.

Inferred from the cumulative change of the magmatic ejection volume of the Mashu volcano over the past 14000 years, three large-scale eruption events occurred at intervals of about 7000 years: Ma-l at 14000 years ago, caldera-formation of Ma-f, g, h, i, and j). After the formation of the caldera, the lava effusion and the explosive eruptions were repetitiously occurred every few hundreds of years to decades. After the formation of the Kamuinupuri central cone about 4000 years ago, intermittent eruption of Ma-c tephras occurred after the longest dormancy period (about 1500 years) in the post-caldera stage. Currently it has been 1000 years since the latest eruption (Ma-b) of 1000 years ago. Considering the characteristics of the eruption history through the post-caldera stage, it may be the time when the magma accumulation is ready and a new eruption event begins.

In the caldera-formation period, the possibility of simultaneous eruptions from several magma chambers was pointed out from the change of the lithic type and the change of phenocryst composition (Wada et al., 2017). In the TiO_2 vs. K_2O diagram of bulk rock composition, the magmas that caused the caldera formation is different from the post-caldera stage and the Ma-l period magmas, suggesting that the magma plumbing system was different only in caldera-forming period.

Estimated from the MELTS program and the mineral thermometers, the silicic magma chambers of Mashu volcano where phenocrysts (plagioclase-pyroxenes-iron oxides) can co-exist in equilibrium is 4-5 kb in pressure, 4-5% H_2O, temperature of 930 ℃ to 970 ℃ are most suitable, which may have not changed significantly during the past 14000 years.

Keywords: Mashu caldera, magma plumbing system, magma chamber

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Eruption sequence of 7.6 ka caldera-forming eruption from Mashu-volcano eastern Hokkaido, japan

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Mashu volcano is located on eastern Hokkaido, Japan. The volcano has a 7.5 km x 5.5 km caldera in the summi. This caldera was formed by explosive eruption at 7.6 ka (Kishimoto et al.,2009; Yamamoto et al.,2010). In the previous geological study, caldera-forming eruption deposits were described as preceding pyroclastic fall deposits Ma-j to Ma-g and pyroclastic flow deposit Ma-f (Katsui et al.1975). Kishimoto et al. (2009) resulted that Mashu caldera-forming eruption consists of initial Phreatomagmatic eruption (Ma-j), followed by Plinian falls (Ma-i~Ma-g), and a catastrophic pyroclastic flow (Ma-f). After that, Hasegawa et al.(2017) subdivided Ma-f into 7 layers (Ma-f1 to Ma-f7 in descending order) suggesting of more complex eruption sequence of Mashu caldera. In this study, we carried out geological survey, grain size analysis and components analysis (for 2~32 mm size grains) to reveal detailed eruption sequence of Mashu caldera.

Ma-f6 and Ma-f7 are pyroclastic density current deposits (PDC), and rich in gray/banded pumice(40~60 wt%,5~21 wt%, respectively).Median (MdΦ) for Ma-f6 and Ma-f7 are -1.00Φ to 0.89Φ.Ma-f5 (pyroclastic fall deposit) and Ma-f4 (PDC) contain a large amount of accretionary lapilli(each 89wt%,82wt%,respectively).Pumice and lithic fragments are coated by silt size ash. MdΦ for Ma-f4 is -0.55Φ to 3.22Φ, that is finer than Ma-f6 and Ma-f7. Ma-f3 is clast supported PDC containing large amount (>90wt%) of lithic fragments. Lithic fragments are composed of dominant dacite, and minor amount of plutonic and altered rock fragments. MdΦ for Ma-f3 is -3.47Φ to -1.37Φ indicating of lack for very fine sand and silt particles. Ma-f2 is PDC often showing cross lamination. Ma-f2 contains a lot of granule sized lithic fragments (70wt%) and pumice (30wt%). MdΦ for Ma-f2 is -1.84Φ to 1.16Φ . Ma-f1 is the brown ash layer, containing pumice (52wt%) and lithic fragments (48wt%). Boundary between Ma-f1 and Ma-f2 is obscure and grain size gradually decrease to the top. MdΦ for Ma-f1 is -1.22Φ to 1.80Φ. Ma-f1 and f2 can be observed above Ma-f3 without exception.

Based on the data, Ma-f1 to Ma-f7 can be grouped as Ma-f7~Ma-f6, Ma-f5~Ma-f4, Ma-f3~Ma-f1 with different eruption styles. Dominant juveniles change from white pumice to banded/gray pumice from Ma-i to Ma-g in ascending order. Componentry of Ma-f7 and Ma-f6 are consistent with the change of those of underlying Ma-i~g suggesting that Ma-i~Ma-6 are sequential products from single Plinian column. Ma-f5 and Ma-f4 show the characteristics of Phreatomagmatic eruption style. After the collapse of Plinian column to generate PDC of Ma-f6 and Ma-f7, the water/magma ratio might be increased and resulted in change in the eruption style. Volume of lithic fragments drastically increase in Ma-f3~1 that infer caldera collapsed occurred in this phase. Lithofacies of Ma-f3 to Ma-f1 correspond to Layer 1~Layer 3 (Wilson,1985) that are typical sequence formed by fluidal, high-energy PDC. In conclusion, caldera-forming eruption sequence of Mashu volcano could not be from single Plinian column but consist of diverse styles of distinct phases as first Plinian, second Phreatomagmatic and final caldera collapse events.

Keywords: tephra, caldera, Phreatomagmatic-eruption, eruption-sepuence

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Geological study of the 1000 yBP Ma-b eruption, Mashu volcano, eastern Hokkaido: Especially for the change of eruption style.

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Mashu volcano is located at the southeastern rim of Kutcharo caldera in eastern Hokkaido, Japan. Mashu volcano began to erupt 35000 yBP (Hasegawa *et al.*, 2009) and the eruptive history of recent 14000 years has been divided into three stages: stratovolcano building stage, caldera-forming stage and central cone building stage (Katsui *et al.*, 1975). Ma-b eruption of 1000 yBP is the largest eruption (VEI=5of) central cone building stage. Ma-b tephra has been divided into six sub unit: Ma-b1~Ma-b6 (Katsui, 1962; Kishimoto *et al.*, 2009), details of its eruption style, eruption sequence and change of magma are not clear. Eruption sequence of Ma-b eruption was reconsidered by geological survey, grain size analysis, component analysis and whole-rock chemical composition analysis.

Based on facies and component ratios, we divided Ma-b tephra into six sub units; Ma-b1 to Ma-b6 in descending order as Kishimoto *et al.* (2009). Ma-b6, the lowest unit of Ma-b tephra, is thin gray-brown ash deposits consisting of pumice, crystals and lithics of sand size. We found it only in one section of northern area of Mashu volcano. Ma-b5 is well-sorted, clast-supported yellowish-white pumice fall deposits. This unit is the largest scale among Ma-b tephra, and distributed in wide area of northern Mashu. Ma-b4 is alteration of comparatively well-sorted ash layer and poorly-sorted lapilli tuff layer with pumice scattered in ashy matrix. Ma-b4 usually contains accretionary lapilli. The lower part of Ma-b4 shows cross-laminated structure, and ratio of pumice increases in the upper part. Then, we consider that Ma-b4 consists of pyroclastic surge and ash fall deposits. Ma-b3 is yellowish-white pumice fall deposits and distributed in the WSW area of Mashu. Ma-b2 is a pyroclastic surge deposit, consisting of pumice and lithics scattered in gray-brown ash deposits, and contains lots of accretionary lapilli. Ma-b1 is a poorly-sorted pumice fall deposit distributed in WSW area. The layer consists of pumice coated by silt size ash, suggesting that it would be supplied from wet column. Juvenile materials of Ma-b tephra are composed of vesiculated pumice and blocky to flaky, blue-gray to black lithic fragments. Matrix of these lithic fragments is fresh and glassy, containing very small bubbles in it. In addition, there also exist small amount of altered lithic fragments. As for juvenile materials, ratios of pumice in Ma-b6, Ma-b5 and Ma-b3 are more than 90%, but Ma-b4 and Ma-b2 contains >70% lithic fragments. On the other hand, Ma-b1 consists of ca. 70% pumice and ca. 20% lithic fragments. These juvenile materials are pyroxene dacite (SiO_2=67.3~69.7% and K_2O=0.6~0.7%), and SiO_2 contents decrease ca. 1% from Ma-b5 to Ma-b1.

From changes of facies of each unit, we considered the eruption sequence of Ma-b as follows. Detail of Ma-b6 is not clear because it distributes in limited area, it is considered that Ma-b6 would be started with small explosion. Ma-b5 is a plinian eruption and discharged pumice fall deposits. This eruption is the largest one through Ma-b. Considering that thickness and grain size become thinner and smaller, the eruption scale of the following eruptions abruptly decrease. Eruption style of Ma-b4 changes to phreatomagmatic eruption by interaction of magma and external water. Flaky texture (Wohletz, 1983) and small bubbles of lithic fragments are consistent with it. Ma-b3 is pumice fall deposits from plinian eruption, but changed to phreatomagmatic again in Ma-b2. Ma-b1 is considered as phreatoplinian eruption and erupted pumice fall deposits coated by ash.

Ma-b eruption repeated phreatomagmatic eruption, suggesting that aquifer may exist under Kamuinupuri

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volcano. Transition of eruption style should be determined by interaction of uprising magma and external water. Eruption rate of Ma-b is the maximum in initial stage, and then phreatomagmatic eruptions frequently occur as decreasing eruption rate.

Keywords: Mashu volcano, tephrostratigraphy, phreatomagmatic eruption, active volcano

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Petrology of the caldera-forming eruption of Nigorikawa Caldera, Southwest Hokkaido, Japan

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The Nigorikawa volcano, which has a caldera approximately 3 km in diameter is located in southwest Hokkaido, Japan. Nigorikawa caldera was formed by ca. 12 ka explosive eruptions. Previous studies by Yanai et al. (1992) suggested that the caldera-forming eruption deposits (Ng) were divided into 4 units: Ng-c, Ng-b, Ng-a fall, Ng-a flow, in ascending order. The reflective index of volcanic glasses increases from Ng-c (bottom: n = 1.489) to Ng-a (top: n = 1.504) (Yanai et al., 1992). However, there is no systematic geochemical data, such as volcanic glass and whole rock chemistries, for Ng units. In this study, we performed field surveys and sampling and determined petrological features for juvenile clasts of Ng units to reveal the caldera-forming magma plumbing system of this volcano.
Ng can be characterized by containing a large amount of hornblende phenocryst. Ng-c is a cross-bedded, pyroclastic surge deposit, which consists of dominant fine ash and rare pumice clasts. We newly divided Ng-b into lower pyroclastic fall (Ng-b fall) and upper pyroclastic surge deposits (Ng-b surge). Ng-a fall and flow are pyroclastic fall showing reverse grading, massive pyroclastic flow deposits, respectively. Although the distribution of Ng-a flow was reported within 5 km around the caldera (Yanai et al., 1992), we found and described Ng-a flow at several outcrops 15 km far from the source. On Ng-a flow, pyroclastic surge deposit was observed. In this study, we refer to it as Ng-a surge. In addition, another pyroclastic flow deposit (Ng-x) containing hornblende phenocryst was discovered above Ng-a surge with intervening thin soil layer at 4.5 km northest from the source. Consistent chemical composition with other Ng units suggests Ng-x was derived from Nigorikawa caldera.
These geological data infer that eruption volume and duration of Nigorikawa caldera-forming eruption could be larger and longer than previously reported, respectively. Juvenile clasts of Ng can be classified into three types: white pumice (WP), gray pumice (GP), banded pumice (BP). We recognized all type of juvenile clasts in all units, and the dominant component is WP. There is no enough petrological data of Ng-c obtained because of fine lithofacies. The phenocryst assemblage of WP is Pl + Hb ±Cpx ±Opx ±Opq ±Qtz, and with hyalopilitic texture. Petrography of GP is almost the same as WP, except for the absent of Qtz, and a groundmass texture of GP is hyaloophitic. In the Harker diagrams, almost of WP (SiO_2 = 61.2 - 63.7 wt.%) and GP(SiO_2 = 54.6 - 57.4 wt.%) plot on a single linear trend, and BP plots between WP and GP. Systematic vertical change of chemical compositions inferred by Yanai et al., (1992) could not be recognized. GP of Ng-b is the most mafic and show a distinct trend from main linear trend, especially in Na_2O-SiO_2, Ba-SiO_2, Zr-SiO_2 diagrams. The volcanic glass composition of WP and white part of BP show common composition as SiO_2 = 71.2 - 78.2 wt.%. Chemical trends of volcanic glass are almost similar to those of whole rock composition. The heterogeneous texture of BP and the existence of three types of juvenile clasts in all units indicate mixing and mingling of different types of magma are main processes in Nigorikawa caldera-forming eruption. Chemical trend converges to felsic side (at SiO_2 = 61.2 - 63.7 wt.%) suggesting single felsic end member magma. On the other hand, two distinct trends for GPs of Ng-b and Ng-a imply that at least two different mafic end member magmas had existed. Magma plumbing system of Nigorikawa caldera-forming eruption might be composed of shallower and larger felsic magma, producing white pumice, and two mafic magmas that successively injected into the felsic magma at different phases.

Keywords: Nigorikawa caldera , Petrology

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Textual analyses for pumice from precursory Plinian eruption of Aira caldera forming eruption

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Aira caldera is located in northern part of Kagoshima bay, southern Kyushu. The caldera forming eruption (29,000 BP) produced Osumi pumice fall (+Tarumizu pyroclastic flow), Tsumaya pyroclastic flow, Kamewarizaka breccia, and Ito pyroclastic flow (+ AT ash). In this study, we focus on bubbles in the ejecta because the vesiculation of magma is a driving force of magma ascent and it is expected that vesicular textures reflect the condition in the magma chamber and in the conduit. The aim of this study is to quantitatively describe the vesicle textures in Osumi pumice fall from Aira caldera forming eruption.
We sampled Osumi pumice fall in Tarumizu, Kagoshima, where the deposits are inclined to the ground, showing a typical mantle bedding structure. Samples were basically taken horizontally by intervals of 50 cm from the lower boundary to the welded part of Ata pyroclastic flow in the total horizontal length of the deposits of 850 cm (totally 18 layers), separately for characteristic two fine grain-rich thin layers (fine 1 and fine 2). Near the upper boundary to the Tarumizu pyroclastic flow, samples were taken vertically by intervals of 30 cm (3 layers).
We selected 8 layers by the equal interval (0 cm, 150 cm, fine1, 300 cm, 450 cm, 600 cm, fine2, 750 cm, +30 cm and +90 cm) and two fine-rich layers for the analysis of grain size distribution by using sieves(-5≦Φ≦1). For bulk density measurements, we selected ten pumices with size range 8~16 mm for each layer (4 pumices for fine 1). The bulk density measurements were conducted by using 3D laser scanner DAVID (3D model construction software) and Hira 3D viewer (calculation software of bulk volume). For the textual analysis, we made 8 chips (each chip includes 2 pumices (maximum and minimum bulk densities)) for 8 layers. We observed vesicle textures by SEM (HITACHI TM3030Plus:15keV). After image processing, we conducted vesicle textual analyses and phenocrysts area measurements by imageJ software.
The bulk density of 10 layers ranges from 0.46 to 1.18 g/cm^3 (maximum difference of 0.6 g/cm^3 at 300 cm layer, minimum difference of 0.2 g/cm^3 at fine 2 layer). We define a bubble with an area of 0.01 mm^2 or more as a pheno-bubble and a bubble with an area less than 0.01 mm^2 as a matrix-bubble.
Matrix-bubbles had three characteristic textures: 1. Single spherical bubbles, 2. Elongated bubbles, 3. Connected bubbles. The vesicularity of 8 layers ranges from 64.8 to 92.7 %. There is a correlation between pheno-bubble abundance and bulk density but no correlation between amount of phenocrysts and bulk density.
The presence of elongated bubbles indicates that bubbles experience a sort of deformation. Connected bubbles in small scale suggest that pheno-bubbles increase their sizes by the coalescence process of bubbles. The correlation between pheno-bubble abundance and bulk density suggests that bulk density is determined by pheno-bubbles. The differences in bulk density in one layer can be thought to result from the differences in pheno-bubble abundance. If pheno-bubbles are the relic of bubbles in the magma chamber before eruption, it is expected that pheno-bubbles heterogeneously distribute by spatial scales of several millimeters in the magma chamber, which triggered the eruption.

Keywords: caldera, vesicularity, pheno-bubble

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Long-term input rate of mafic magma inferred from a long-term heat balance model of silicic magma reservoir

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A model, which represents a formation dynamics of eruptible silicic magma reservoir made from partially melted crystal rich mush in the upper crust generated by inputs of mafic magmas supplied from mafic magma reservoirs accumulated in the lower crust, is beeing generalized (e.g. Sparks et al., 2019). According to this model, it is likely that an eruption of felsic magma is caused by inputs of mafic magmas. Knowing the input rate of mafic magma is, therefore, important not only for an understanding the magma dynamics but also for a long-term evaluation of eruption possibility. Koyaguchi and Kaneko (2000) proposed the concept, and discussed the development process of the silicic maga subdivided into two stages: the stage of rapid rise in the temperature, partial melting, disturbance, rapid cooling of the felsic magma due to the input of mafic magma (Convection & Melting (C & M) mode), and the subsequent conductive cooling stage (Conductive Cooling (CC) mode). In this paper, I would like to suggest that we may be able to estimate a long-term mafic magma input rate using an improved model of long-term heat balance of the CC stage if a magma reservoir size is obtained underneath the volcano with known eruption rate during the past thousands of years observed by the geological study.

The basic formulas of the model are following equations:
$\Delta Q = I\rho\{cT_b + L(1 - \phi_{crit})\} - E\rho cT_{eft}$, (1)
$Q_{loss} = 2\pi\{a + b(tanh^{-1}e/e)\}k(T_{eft} - T_{wrt})$. (2)
Here, ΔQ is the difference between the power of the erupted magma (E: long-term eruption rate; km^3/kyr) and that of the input magma (I: long term input rate; km^3/kyr), and Q_{loss} is the power dissipation of the oblate spheroid shape magma reservoir. a is a major axis of the spheroid, b is its minor axis, and e is the eccentricity. ρ is the density of the rock, c is the specific heat of the rock, L is the latent heat of fusion, k is the thermal conductivity, ϕ_{crit} is the melt fraction of the eruptable magma, T_b is the temperature of the mafic magma, T_{eft} is the effective temperature of eruptible magma, T_{wrt} is the crustal temperature around the magma reservoir. Furthermore, assuming that ΔQ can not be completely consumed by Q_{loss}, the residual power Q_{ex} is: $Q_{ex} = \Delta Q - Q_{loss}$ (3) and that of the volume increase rate (R_{ex}; km^3/kyr) is: $R_{ex} = Q_{ex} / \rho cT_{eft}$ (4).

Next, I conducted to calculate the supply rate of mafic magma by assuming concrete cases using this model. For example, if a = 3600 m was observed underneath a volcano which was geologically obtained the long-term eruption rate of 0.1 (km^3/kyr), the magma input rate for maintaining the magma reservoir size (Q_{ex} = 0) was calculated to be 0.5 (km^3/kyr), assuming that T_{wrt} = 100 ˚C, the flatness ratio of the magma reservoir was 0.7 (1-b/a) and other parameters were refferred to Koyaguchi and Kaneko (2000). This model, however, has a large dependency on T_{wrt}. For example, if the same injection and input rate were assumed as above instance, it balanced at a = ~ 20 km when T_{wrt} = 500 ˚C. With this model, although there is a large temperature dependence of the surrounding crust, it could be shown that the long-term input rate of mafic magma during the past thousands of years can be estimated by knowing the present size of the magma reservoir underneath the volcano with the known eruption rate.

Keywords: heat balance model, long-term eruption rate , long-term magma input rate, size of magma reservoir

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Outgassing and Oxidation processes of viscous magmas inferred from micro-Raman and IR spectroscopy

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Silicic volcanism ranges from explosive to effusive. Understanding what controls in such activity is an important issue to explain the explosive-effusive transition. The recent observation on Cordon Caulle (Chile, 2011-12) reported the explosive-effusive hybrid activity (Schipper et al., 2013), and we can consider that this eruption style reflects heterogeneous processes such as vesiculation and outgassing in volcanic conduit. Obsidian can be observed as pyroclastic and effusive-lava products of such a silicic and viscous magma eruption, and we can consider that obsidian contains the heterogeneities in rock textures such as crystallinity, water concentration oxidation state, and structure of glass networks. Thus, we performed the micro-Raman and IR spectroscopy on obsidian in order to discuss the heterogeneous processes recorded in rock texture.
At the Akaishiyama obsidian lava on Shirataki, northern Hokkaido, Japan, we can observe the red-colored oxidized obsidian mingled with black-colored obsidian. The mingled obsidian shows various contrasts and distributions on the hand specimen, and we can consider that such various oxidation texture reflects the different mechanisms of outgassing and oxidation during the eruption. In this study, we used the microRaman and IR spectroscopy to characterize the oxidation state in the obsidian. We obtained the 2 types of Raman spectra of oxide microlites in red and black obsidians, respectively. Compared with referential spectra, we identified the captured spectrum as magnetite and hematite. Furthermore, the height of 470 cm^{-1} on the glassy part shows the degrees of oxidation. The IR spectroscopy shows the different water concentration between red-colored and black-colored obsidian glasses. The red-colored oxidized glass shows lower water concentration than black-colored obsidian glasses. Based on the analytical results of microRaman and IR spectroscopy and, we discuss the formation process of heterogeneous oxidation textures during the eruption.

Keywords: Oxidation texture, Raman spectroscopy, IR spectroscopy, obsidian

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Distribution of ballistic blocks during the 2014 eruption of Ontake Volcano, central Japan

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The 2014 eruption of Ontake Volcano, central Japan killed 56 people for ballistic blocks. We entered near the crater after this eruption, investigated the size and distribution density of ballistic blocks. This eruption formed the new craters extending about 0.8 km from the northwest to southeast. From the distribution of ballistic rocks, it became clear that they were released from the new craters located in the Jigokudani. It is within 0.9 km radius from its new craters that these ballistic blocks are distributed high densely (> one/m^2). The area where fatalities occurred from this eruption was consistent with the area where such ballistic blocks fell at high density. The size of the largest ballistic rock is 96 ×70 ×64 cm. It is commonly observed in other phreatic eruptions in the Japanese Islands that ballistic rocks fall at high density within about 1 km from the crater. Therefore, in order to prevent severe damage of ballistic rocks due to phreatic eruption, it is necessary to leave 1 km from the crater.

Keywords: Mt. Ontake, eruption, ejected material, distribution density, damaege, hazard mitigation

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After 2014 eruption, The volcanic crustal deformation around Mt. Ontake

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On September 27, 2014, the Mt. Ontake occurred a phreatic eruption. The eruption made fifty-nine casualties and still five missing persons. Because the phreatic eruption makes a smaller signal than a magmatic eruption, a phreatic eruption is harder to predict than a magmatic eruption. For this reason, understanding of the phreatic eruption is essential for the mitigation of volcanic hazard. The observed crustal deformation of Mt.Ontake detected the inflation of the mountain related to the 2007 small eruption. In actually, the NE-SW baseline, which is crossing the Mt. Ontake (Ochiai Karatani - Ontake Tanohara), extended about 2cm at the 2007 event. During 2007 and 2014, the length of the baseline did not change. After the 2014 event, the baseline is contracting about 1cm/yr. The contracting is continue to 2019, and the length of the baseline reaches before 2007 eruption. Also, detected crustal deformation in 2007 event is more extensive region than the 2014 event. Takagi and Onizawa (2016) make two dikes model from observed crustal deformation in 2007 and for the 2014 event two dikes and a small shadow pressure source model. We point out the effect of topography for the shallow source estimation because Takagi and Onizawa (2016) used GNSS observation sites at the foothills where locate over 4km far from the summit of Mt.Ontake. By the way, we developed new five continuous GNSS sites around the foothills of Mt. Ontake after the 2014 eruption and started 11 campaign GNSS observation near the summit region at 2016. The local GNSS observation revealed narrow deformation, which is about 10cm contraction between about 1 km distance GNSS sites from 2017 to 2018. The GNSS sites locate at within about 1km distance from the 2014 crater of Mt.Ontake. The GNSS observation near the summit is essential because the GNSS result suggests the shallow pressure source. The shallow pressure source estimation is affected by topography. In the presentation, we evaluate the topographic effect of the Mountain using three-dimensional Finite element method (FEM). We present the estimate pressure source under considering a topographic effect.

Keywords: Mt.ontake

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Geological and petrological study of Kariba volcanic group: Elucidation of the volcanic history and changes of magma

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Kariba volcanic group, act in Pleistocene, is situated at the northwestern part of the Oshima Peninsula, southwestern Hokkaido. Volcanic centers of the individual edifice are distributed over the range of about 7 km from north to south and about 10 km from east to west, and present peak is Mt. Kariba, 1520 m height. There are several previous works (Yamagishi and Kurosawa, 1987 and Kaneoka et al., 1987), suggesting that Kariba volcanic group is divided into two edifices; Anatokomae lavas (0.7 Ma) and Karibayama lavas (0.25Ma). Whole-rock compositions were also reported by Nakagawa (1992) and Kosugi et al. (2013). However, volcanic history and petrological characteristics of the Kariba volcanic group have not been discussed. The purpose of the study is to reveal the history of the volcanic edifice and the transition of magma. First, we observed aerial photographs and conducted geological survey (divide each eruptive unit, check geological relationships and degrees of dissection of these units). We also collected samples and determined petrographic features, whole-rock major and trace element compositions and Sr-Nd isotopic ratios. Furthermore, we are analyzing K-Ar ages for 5 samples.

Then, we divided volcanic ejecta of Kariba volcanic group into 12 units according to the estimated eruptive centers and these strata, and these units were sorted into 3 stages by reported K-Ar ages, estimated ages from these strata and degrees of erosion, and petrological characteristics. Stage 1 was a subaqueous activity and lavas flowed down to the westward. Subsequently, activity shifted completely to subaerial condition. The vent positions scattered throughout the edifice during the Stage 2, volcanic centers concentrated into the center of the edifice during the Stage 3. As a result, shield volcano with flat edifice was formed at Kariba volcanic group.

The eruptive rocks are composed of basalt to andesite and are classified as high-K and calk-alkaline series. Mafic inclusions are found in all stages. Negative Nb and Ta anomalies and depleted Sr-Nd isotopic ratio of the rocks are similar to the back-arc volcanoes of northeastern Japan arc, especially to Oshima-Kojima (Kosugi et al., 2013). Petrological characteristics of host rocks are different in each stage. Stage 1 lavas are quartz-biotite-olivine basaltic andesite and their SiO_2 contents concentrate in a narrow range. In addition, Stage1 rocks show high Sr, low Nd isotopic ratios compared to Stage 2 and Stage 3. Stage 2 lavas consist of orthopyroxene-bearing olivine-quartz-amphibole-clinopyroxene-biotite andesite and Stage 3 rocks are orthopyroxene-bearing quartz-clinopyroxene-amphibole-olivine-biotite andesite. Stage 2 and Stage 3 rocks make different trends in many Harker diagrams, and Stage 3 ones are rich in MgO. On the other hand, mafic inclusions have wider compositional range than those of host rocks, and there is no difference among the stages. Existence of mafic inclusions, disequilibrium mineral assemblages such as quartz and olivine, dusty and oscillatory zoning in plagioclase indicate that magma mixing was the main magmatic process. Moreover, different trends of host rocks in each stage indicate that mafic and felsic end-member magmas should be different; Stage1 is basalt and basaltic andesite, Stage 2 and Stage 3 are basalt and andesite but those of Stage 3 are richer in MgO content than those of Stage 2.

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Keywords: Kariba volcanic group, Southwestern Hokkaido, K-Ar dating, whole-rock chemistry, back-arc volcano

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Stratigraphy and evolutionary mechanism for the low-K tholeiitic magmas at Kotakakura volcano in the Sengan geothermal field, Northeast Japan arc

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Background and purpose

Kotakakura volcano is a Quaternary stratovolcano located in the Sengan geothermal field, Northeast Japan arc. It consists of low-K tholeiitic series, and has a K-Ar age of 1.2 to 2.3 Ma (Suto and Ishii, 1987). In order to elucidate the mechanisms that cause the compositional variations of low-K tholeiitic magmas in Northeast Japan arc, geology and stratigraphy along with petrology and petrography on the Kotakakura ejecta are revealed with high resolution. The crystallization differentiation of phenocrysts has been considered as the chi of mechanism to create the characteristic tholeiitic variation trend. It is basically true for the case with the Kotakakura ejecta, either crustal assimilation or mixing of felsic magma has considerable role acted effort in several lava flows in the early stage of development.

Geology

Kotakakura volcano consist mainly of lava flows. On the basis of presumed eruption center deducted from flow directions, the ejecta is roughly divided into Kotakakura East lava group (KTE) and Kotakakura North lava group (KTN). The KTE and KTN are subdivided into 16 and 7 lava flows, on the bases of the topography of the individual lava robe, stratigraphic relations, and lithofacies, as well as petrological features, petrography and bulk chemical compositions. Although we can not confirm the direct covering relationship, we infer that KTN is covered by KTE from the remaining state of the terrain at the boundary. In addition, the KTN suffered weathering erosion of outcrops heavily compared with KTE, so that the KTN is considered to be effused earlier than KTE.

Petrological data

Petrography

The KTE lavas commonly contain Plagioclase, Orthopyroxene, Clinopyroxene, opaque mineral, as phenocryst phases. Olivine are found only in KTE1 to 3. The amount of phenocrysts varies from 16.9 to 48.5.

The KTN lavas commonly contain Plagioclase, Orthopyroxene, Clinopyroxene, Opaque mineral, as phenocryst phases. Phenocryst-sized quartz grains are found only in KTN1, 1'. The amount of phenocrysts varies from 19.8 to 41.5.

Major elements

The SiO2 content varies from 49.1 to 60.9, and almost all the ejecta come within the low-K basalt to andesite clan on the Harker diagram. Both the KTE and KTN lava samples come within the range for the tholeiitic series in the northern subzone of the Nasu (frontal) volcanic zone in the NEJ (Kawano et al., 1961), with slightly high Al2O3 and CaO, and low FeO*, MgO, and Na2O levels compared with the average TH trend in the NEJ.

Almost all the Kotakakura samples are plotted in the area for the tholeiite (TH) series on the Miyashiro's diagram. The exceptional two samples also come low-SiO2 extension of the trend for the Kotakakura TH series. The KTE samples show typical variation trend for the low-K tholeiite series in the Northeast Japan arc (NEJ). The KTN samples, on the other hand, show somewhat peculiar trend; the FeO*/MgO decreases slightly with increasing SiO2.

Trace elements

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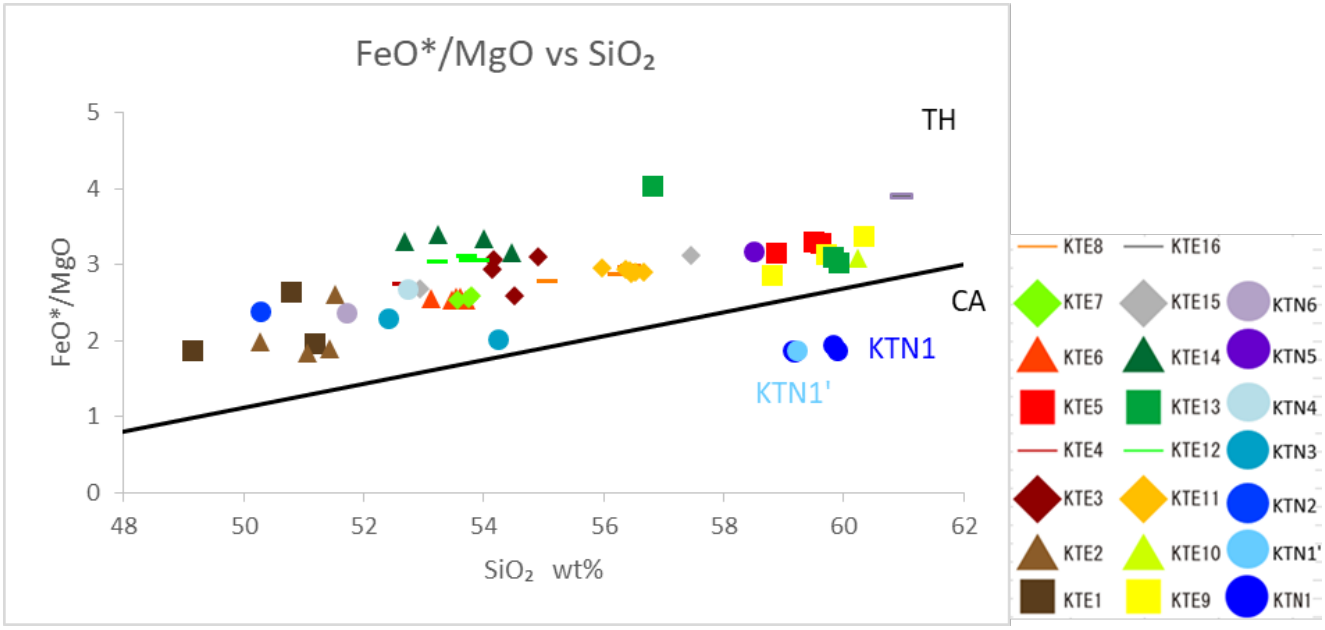
The KTE samples show virtually the same incompatible element characteristics as those typical for the TH in NEJ. The KTN samples basically share the characteristics with the coexisting KTE, but only Y kept almost constant through the whole SiO2 range of the KTN variation.

Discussion

Because the KTE shows the typical tholeiitic variation trend which share the TH series in NEJ, a crystallization differentiation modeling was examined using mass balance calculation by employing phenocrysts as the fractionated phases. The results successfully reproduce the actual variation trends for the KTE. The KTE did not become more evolved composition with descending order of eruption, suggesting that either intermittent supply of primitive tholeiitic magma into the differentiating chamber, or liquid differentiation caused by boundary-layer convection at the chamber wall acted as the additional role in the compositional variation process of the KTE.

As for the KTN peculiar trend, it may be due to incorporation of some quartz-bearing silicic component into the differentiating tholeiitic magma. Such silicic component might be either the Tamagawa dacitic welded tuff that lies under the Kotakakura volcanic edifice, or rhyolitic partial melt of crustal origin.

Keywords: stratigraphy, tholeiitic magmas, crystallization differentiation, magma mixing



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Pre-eruptive magmatic processes of upper part of Goshikidake pyroclastic rocks, Zao volcano

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Zao volcano is the active stratovolcano, which has many eruption records before 1940. Precursory phenomena, such as volcanic tremors and earthquakes, have been detected since 2013. Therefore, it is necessary to examine pre-eruptive magmatic processes to understand the current situation of this volcano. In this study, we revealed pre-eruptive magmatic processes on the Okama crater eruption products from 800 years ago to present, by detailed petrologic examination including kinetic modelling of chemical zoning and thermodynamic approach.

Eruption products are pyroclastic surge deposits with periodically existing bomb concentrated layers. The rock samples are basaltic andesite to andesite, including plagioclase, orthopyroxene, clinopyroxene and magnetite as phenocryst. Olivine with reaction rim of clinopyroxene rarely observed. Rocks are classified into medium-K, calc-alkaline series showing liner trends in Harker diagram. Plagioclase: core are An64-86 (peak value: An68, 74), the rim are An_{60-86} ($An_{64, 70, 76}$), and groundmass are An_{57-80} (An_{63}). Orhopyroxene: core are Mg#=60-75 (Mg#=65), the rim are Mg#=64-76 (overgrouth rim is Mg#=65, Mg rich rim is Mg#=71), and groundmass are Mg#=63-67 (Mg#=64). Clinopyroxene: core are Mg#=64-67, and rim are Mg#=64-76. Magnetite: core are Mg/Mn=7-21 (Mg/Mn=12-14), and rim are Mg/Mn=8-18 (Mg/Mn=11, 15). Plagioclase was classified into four types; C-type: homogeneous core with or without normal zoning (core composition An_{70-80}), P-type: patchy-like heterogeneous/oscillatory zoned core (An_{70-75} and An_{60-66}), D-type: having dusty zone (An_{75-90}) on the rim, H-type: honeycomb core (An_{75-85}) and low An rim (An_{60-65}). Orthopyroxene was classified into four types; L-type: low-Mg (Mg#=60-67) core sometimes having normal zoned rim, R-type: low-Mg core having reverse zoned rim. M-type: small phenocryst with medium Mg core sometimes having normal zoned rim. H-type: heterogeneous core with high (Mg#=70-76) and medium parts. R-type is subdivided into subtype-I: thin high-Mg (Mg#=71-76) rim, subtype-II: medium-Mg and Al (Mg#=69-70) broad rim, and subtype-III: medium-Mg and low-Al broad rim. Estimated temperature for low, medium, and high-Mg parts by two-pyroxene geothermometer are 950-1000℃, 1010-1040℃, and 1030-1060℃.

All rocks were formed by mixing between low temperature and high temperature end-member magmas (LT and HT-magmas). The estimated compositions of end-member magmas by using rhyolite-MELTS algorithm were as follows; LT-magma: SiO_2=48.0-50.0 wt.%, T=953-999℃, P=1.5 kbar, H_2O=1.0-2.0 wt.%, HT-magma: SiO_2=59.0-62.0 wt.%, T=1060-1126℃, P=1.5-2.0 kbar, H_2O=1.0-2.0 wt.%. The stable mixed magma (M-magma) where the rim precipitated would be formed in the chamber. We note the Mg-medium and high rim would be formed from Mg-richer mixed magma which would appear from injection of HT-magma to form M-magma. By comparing observed and calculated zoning profiles, we estimated the residence times of orthopyroxene phenocrysts in the M-magma. We assumed the temperature and oxyegen fugacity conditions are 1025℃ and was NNO-buffer. The initial profile of Mg# for orthopyroxene crystal is drawn based on the zoning profile of Al. The estimated residence times of R-type (I) crystals are 0.5 days to 2 years and those of R-type (II) and (III) crystals are 5 to 20 years. In terms of plagioclase phenocrysts, zoning profiles show that several patterns of correlation between MgO and An in core. These would reflect that the multiple magmatic processes in the mixed magma.

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Keywords: magma plumbing system, residence time, rhyolite-MELTS, chemical zoning, orthopyroxene, Zao volcano

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Geology and petrology of Futamata volcano, Nasu volcano group, NE Japan

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Futamata volcano (FV) composes Nasu stratovolcano group (NSG), NE Japan. The activities of NSG started from Kasshiasahi-dake (540-420ka), and the locus of eruptions shifted to south forming Sanbon-yari-dake (360-270ka), Asahi-dake (170-70ka), Minamigassan (210-80ka) and Chausu-dake (16ka-present). However, FV (140-90ka) was the only unique volcano formed in the northern part of NSG (Ban & Takaoka, 1995; Fujita, 1988; Yamamoto, 1999). In order to reveal the eruption history and magmatic processes, we performed geological and petrological study for Futamata volcano.
Yamamoto (1999) defined an outline of stratigraphy of FV as consisting of Iwayama lava flow, Futamata pyroclastic flow deposit and Futamatayama lava dome in ascending order. In this study, we revised the Iwayama lava flow into 12 units by geomorphology, distribution and mineral assemblages: FLN (north: 3 units), FLW (west: 3 units) and FLS (south: 6 units); Futamata pyroclastic flow deposit can be divided into 2 units: FBW (west) and FBE (east), and Futamatayama lava dome into 2 units: FOD and FMD. We summarized these units into two stages by combining geological and petrological data, such as first lava flow stage (S1) and second lava dome stage (S2). The S1 is composed of FLN, FLW, FLS and FBW. S2 consists of FOD, FMD and FBE.
Mafic inclusions are common in all ejecta of FV, and they often show quenched margins at the boundary with host rocks. The host rocks of S1 are mainly quartz-bearing olivine clinopyroxene orthopyroxene andesite to dacite. On the other hand, host rocks in S2 are clinopyroxene orthopyroxene andesite to dacite, and they sometimes contain hornblende. SiO_2contents of host rocks of S1 and S2 are in the range of 53.5 to 68.4 wt.%. Mafic inclusions of both stages are predominantly olivine clinopyroxene orthopyroxene basalt to basaltic andesite. Their SiO_2contents range from 50.6 to 59.3 wt.%.
Chemical difference between two stages is clearer at mafic inclusions on Miyashiro (FeO*/MgO vs. SiO_2) diagram. Each stage forms a distinctive linear trend subparallel to one another (S1: FeO*/MgO = 1.9; S2: FeO*/MgO = 2.2, at SiO_2= 64.1 wt.%), and mafic samples of S1 and S2 can be categorized as calc-alkaline and tholeiitic series in the diagram respectively. On a plot of K_2O vs. SiO_2, chemical trends between two stages diverge on felsic compositions. K_2O composition of S1 is larger than that of S2 at a given SiO_2 content (S1: K_2O = 1.6 wt.%; S2: K_2O = 1.3 wt.%, at SiO_2= 63.8 wt.%). Cr contents of S1 mafic samples are remarkably higher (Cr = 120 - 180 ppm) than those of S2, characterized by depleted Cr concentration (Cr = 32 - 66 ppm) below 55 wt.% SiO_2contents.
Different trends between the two stages in the FeO*/MgO vs. SiO_2diagram suggests that each eruptive stage was derived from a distinct magma system rather than a single long-lived magma system. Heterogeneous features of host rocks with mafic inclusions in all units indicate that felsic and mafic magmas coexisted and mingled. Mixing processes of different magmas are also supported by disequilibrium phenocryst assemblage, such as olivine and quartz at the same unit. At least four end members can be assumed at FV: S1 mafic/felsic, and S2 mafic/felsic. S1 and S2 felsic end members can be characterized as bearing quartz and hornblende, respectively, on the basis of phenocryst assemblages of host rocks. No changes in the ratios of incompatible elements between S1 and S2 mafic samples, and depletion of Cr contents of S2 mafic samples suggest that more evolved, that is fractionated, mafic magma could be injected and mixed with felsic magma at the later stage (S2).

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Keywords: Futamata volcano, Nasu volcano group, ejecta stratigraphy, magma plumbing system

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Magma of the Haruna-Caldera forming eruption in view of Shirakawa pyroclastic flow deposits-

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Haruna Volcano is a composite volcano which is located in the southern end of the NE Japan arc. Geshi and Takeuchi (2012) divided its whole activity into older activity (-240ka), and newer activity (45ka-). Newer activity began with the Haruna-caldera forming eruption that produced pumice flow (1.0km^3 DRE) and pumice fall (0.2km^3 DRE)(volumes after Yamamoto (2013)). Oishi *et al.* (2011) classified the flow deposits into "Shirakawa" and "Satomi" based on the reflactive indices of plagioclase. The purpose of this study is to clarify the eruption triggering process and magma behavior in the reservoir prior to the caldera eruption in view of Shirakawa pyroclastic flow deposits. We also compared our data with those of Satomi pyroclastic flow deposits (Okano and Suzuki, 2019; JpGU).
Referring to preceding studies (e.g. Oishi *et al.*, 2011), we surveyed 12 outcrops of summit, northern foot and southeastern to southern foot. We could observe the basal part along with upper part only in Koujin outcrop. We sampled juvenile pumice clasts at 8 outcrops. The pumices were classified into white pumice and gray pumice. The gray pumices were typically observed in the basal part of the Koujin outcrop along with white ones. The whole rock SiO_2 contents of pumices varied between 61.9 and 65.4 wt.% (N=44), indicating that they are dacite. The composition does not vary with pumice color and the horizon in the Koujin outcrop. We also note the pumice clasts of Shirakawa pyroclastic flow deposits and Satomi pyroclastic flow deposits (62.8-66.3 wt.% in SiO_2) are not indistinguishable.
Pumice clasts have Pl + Qt + Hb + Opx + Cum + Fe-Ti oxides as phenocrysts, all of which form aggregates. This means that these crystallized in equilibrium. Some phenocrysts have disequilibrium texture such as dissolution of Qt, dusty zone of Pl, aggregates of small Opx (after dehydrogenation decomposition of Hb). Change of melt composition to less-fractionated direction can be the cause for the disequilibrium textures. Decompression can be the additional case for the decomposition of Hb (Rutherford and Hill, 1993). However, we deny the decompression origin, because magmas seem to have ascended very rapidly in conduit judging from absence of groundmass microlites in most pumices. Less-fractionated melt can be generated by either heating by hotter magma or mixing with hotter magma. For the magma mixing, we propose the hotter magma was aphyric since we have not observed phenocrysts derived from the hotter magma. On the other hand, Hb margin on Opx (both ordinary phenocryst, and small-orthopyroxene aggregates) recorded decrease of temperature, although some phenocrysts and aggregates lack in the Hb margin. Appearance of above texture does not vary with pumice color. Above textures are also found in pumices of Satomi pyroclastic flow deposits. Based on above, we propose the magmatic processes in the reservoir just prior to the caldera eruption. First, temperature of felsic magma reservoir rose due to the hotter magma. The change of melt composition due to heating or mixing occurred inhomogeneously (less-influenced zone and more-influenced zone). The crystals in the more-influenced zone came to have reaction rims. In the last, crystals from two zones came to coexist in a pumice due to syneruptive mixing of the two zones. We infer that Hb margin on small-orthopyroxene aggregates formed when magmas of two zones mixed.
We lastly clarify the difference between white and gray pumices. Groundmass microlites are absent in white pumices, whereas microlites are present in gray pumices. We thus judge the difference in color is due to different groundmass crystallinity (Gardner *et al.*,1998). Since gray pumices occur in basal part of

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the deposits, we propose that slow ascending of magma along with conduit formation, that probably occurred before the onset of the caldera-forming eruption, led to formation of gray pumices.

Keywords: Haruna volcano, Pyroclastic flow, Magma mixing, Heating from hotter magma, Eruption trigger

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Magma plumbing system in the caldera-forming eruption of Haruna volcano indicated by Satomi pyroclastic flow deposit

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Haruna volcano is a large stratovolcano, located at the southernmost point of the NE Japan arc. Geshi and Takeuchi (2012) divided its activity into two stages (older and newer period). Haruna volcano had not erupted for 200,000 years after the older period. The activity of the newer period began at 45 ka with Haruna-caldera-forming eruption. This eruption emplaced 1.2 km^3 DRE of pyroclastic fall and flow deposit (Yamamoto, 2013). Oishi *et al.* (2011) showed the pyroclastic flow deposit can be divided into two groups, Satomi and Shirakawa pyroclastic flow deposit, based on the refractive indices of plagioclase phenocrysts.

Structure of magma plumbing systems and the triggering mechanisms of eruptions are basic knowledge to characterize eruptive activities in each volcano. Petrological studies on the ejecta have been used for understanding them. Such studies lead to the forecasting of future eruptions, which is strongly requested by society. Unfortunately, limited petrological studies focusing on detailed petrography have been conducted for Haruna volcano, except the study of the middle sixth century eruption (Suzuki and Nakada, 2007). With this motivation and background, we investigated the Satomi pyroclastic flow deposit of 45 ka Haruna-caldera-forming eruption.

In this study, pumice blocks of Satomi pyroclastic flow were sampled at three sites of the southern foot of Haruna volcano. The samples were classified as white pumice, gray pumice, whitish gray pumice and grayish white pumice. These have whole-rock compositions ranging from 62.8 to 66.3 wt.% in $SiO_{2,}$ showing that these pumices are dacite. There is no great difference among four types of pumice in whole-rock compositions. Compared with the data on pumices of Shirakawa pyroclastic flow (Kitani and Suzuki, 2019; JpGU meeting), there is no great difference too. Four types of pumice show phenocryst assemblages of Pl + Qt + Hb + Cum + Opx + Fe-Ti Ox. This indicates that these minerals crystallized in equilibrium. There is no great petrographical difference among four types of pumice. Dusty plagioclase and resorbed quartz phenocryst suggest that temperature of the melt surrounding the crystals rose. Temperature of the melt rises when (1) the felsic magma mixes with mafic magma or (2) the felsic magma is heated by mafic magma. Now, the pumices don’ t contain any phenocryst which crystallized from mafic magma like olivine, so if the felsic magma mixed with mafic magma, the mafic magma should be aphyric. Meanwhile, texture of orthopyroxene has recorded fluctuations in temperature of the melt.

We analyzed phenocryst mode of white pumices sampled at Matsunozawa with broad whole-rock compositions (3.6 wt.% in SiO_2). They are strongly porphyritic with 52.3-71.7 vol. % phenocryst, indicating that the magma erupted them was mush-like. It turned out that as whole-rock SiO_2 content increases, phenocryst content increases. The phenocryst content increase is accompanied by quartz increase and Fe-Ti oxide decrease. It might mean the difference in mixing ratio with mafic magma if the felsic magma mixed with mafic magma.

Based on the above, we estimated the state of magma plumbing system of Haruna-caldera-forming eruption. Firstly, there is a mush-like felsic magma which contains crystals above-mentioned. Secondly, mafic magma was injected into felsic magma. As a result, felsic magma mixed with mafic magma or was heated by mafic magma. This temperature rising event might have triggered the eruption.

Pumices contain many crystal fragments. It is assumed that high shear stress at the conduit walls promoted crystal fragmentation. Thus, the origin of gray pumices which contain more crystal fragments

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than white pumices might be the magma which had ascended along the conduit margins where the shear stress is highest.

Keywords: Haruna volcano, Caldera-forming eruption, Pyroclastic flow, Mush-like felsic magma, Magma mixing, Heating from hotter magma

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Petrology of the Minamiryu-ga-banba in Hakusan Volcano

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The Minamiryu-ga-banba Lava dated at 30 Ka extends from 100 m below a scoria cone on the southern foot of Gozengamine 4 km downslope to Nakahanba. A scoria raft was found on the Minamiryu-ga-banba Lava 1.5 km from the vent, which has identical whole-rock and mineral compositions to the remnants of a scoria cone on the southern slope of Gozengamine. This indicates that the scoria cone is the source vent of the Minamiryu-ga-banba Lava. We report results of whole-rock and mineral analyses of Minamiryu-ga-banba Lava and the scoria cone at the foot of Gozengamine.

Thirty-six samples of scoria clasts from the cone and raft and Minamiryu-ga-banba Lava were examined under an optical microscope and analyzed by XRF and by EPMA. Lava samples contain phenocrysts of plagioclase, orthopyroxene, hornblende and magnetite set in the groundmass of plagioclase, clinopyroxene, olivine, quartz, ilmenite and glass. Scoria carries phenocrysts of plagioclase and olivine with a small amount of hornblende and orthopyroxene. Plagioclase with or without dusty zone is present. Hornblende phenocrysts are opacitized. The groundmass contains abundant glass and vesicles. Scoria raft contains plagioclase and olivine phenocrysts in the groundmass of abundant glass and vesicles.

Whole-rock SiO_2 of scoriae of the raft and cone largely overlaps, ranging from 55 wt%–60 wt%, while the Minamiryu-ga-banba Lava shows a limited range of 60 wt%–62 wt%. The lava and the scoriae form a single liquid line of descent with decreasing TiO_2, FeO, MnO, MgO, CaO and P_2O_5, increasing Al_2O_3 and K_2O and invariant Na_2O, with increasing SiO_2. These variations could be interpreted by crystallization differentiation of phenocrystic phases except TiO_2 and K_2O, which requires end component with higher TiO_2 and K_2O. The whole-rock compositions of the Nohi Ryolite, basement of the Hakusan Volcano, plot on the extension of lines connecting the scoriae and the Minamiryu-ga-banba Lava. This strongly suggests contamination of the Minamiryu-ga-banba Lava by the Nohi Ryolite.

Plagioclase has An34-61 with a peak An42 in the raft and An36-61 with a peak An42 in the cone. Olivines in the raft and the cone have Fo69-86 with a peak Fo85 and Fo76-86 with a peak Fo84, respectively, and orthopyroxenes in the raft and the cone show Mg#62-84 with a peak Mg#64 and Mg#62-75 with a peak Mg#63, respectively.

Whole-rock and mineral compositions of the scoriae of the raft and the summit cone are essentially identical and were parts of a scoria cone formed by an earlier Strombolian phase, which was subsequently destroyed by extruding Minamiryu-ga-banba Lava.

Although the Minamiryu-ga-banba Lava is dated to 30 Ka by K-Ar method, the lava preserves the original flow morphology as clear as the 2.2 Ka Shiramizunotaki Lava. In addition to this, the summit scoria cone exposes on the surface and is neither covered by soil nor later tephras. Besides this scoria cone, the only known mafic tephra carrying olivine phenocrysts is the Minamiryu Tephra, that has a easterly dispersal axis and widely covers Murodo, Midagahara and Minamiryu-ga-banba. Although the source vent of Minamiryu Tephra is considered to be in the summit region now buried by the Kengamine, our

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observations suggest a correlation of the summit scoria cone and the Minamiryu Tephra. This means that the Hakusan Minamiryu eruption at 2.2 Ka was much larger in magnitude and formed not only the Shiramizunotaki Lava, Kengamine and the Hakusan Minamiryu Tephra, but also the Minamiryu-ga-banba Lava.

Keywords: Hakusan volcano, scoria, scoria raft, lava flow

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Tephrochronological relations of Middle-Pleistocene tephra derived from Myoko Volcanic Group and the pumice and scoria fall deposits found in Kosha Volcano, Central Japan

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Kosha Volcano, locating between Iiyama Basin and Nagano Basin, is a small stratovolcano erupted between 0.3 and 0.2 Ma (Kaneko et al. 1989). There are no geological studies about this volcano after Saito (1955) until Kaneko et al. (1989). Togashi and Akabane (1991) reported two tephra groups within Kosha Volcano. The lower is named Kosha Pumice flow and fall deposits (Kf/Kp), which consists of four pumice layers (A1-A4) with hornblende crystals. The upper consists of four pyroxene-rich scoria layers (A5-A8). They inferred A5- A8 are derived from another volcano locating in the west. They presumed that Kf/Kp originated in Iimori-yama Lava Dome (IM) which is the last product of Kosha Volcano because of presence of hornblende crystals. However, Kf/Kp does not include clinopyroxene crystals, which are common mineral in all of the Kosha products including IM. Hayatsu et al. (1994) and Suzuki (2001) reported several tephra layers distributed around Myoko Volcanic Group. In particular, Ojika Scoria Group (OS) derived from Kurohime volcano and Iz-KT tephra group derived from Iizuna Volcano is possible to correlate to tephra layers at Kosha Volcano.

In order to clarify the origin of these tephra layers, we carried out mineralogical analysis (Takasugi et al. 2018, Fall meeting of the volcanological society of Japan). The results indicated that A5-A8 scoria groups are correlated to OS. Chemical compositions of orthopyroxene and hornblende of A3 and A4 tephra differed from those of Kosha products including IM, suggesting that A3 and A4 are not originated from Kosha volcano. Geological occurrences, mineral assemblages and chemical compositions of orthopyroxene and hornblende crystals of A3 and A4 tephra were very similar to those of KTa tephra, which composes the upper most layer of Iz-KT, suggesting that A3 and A4 tephra are correlated to Iz-KT tephra group. This time, we determined chemical compositions of Iz-KT layers to correlate tephra layers at Kosha Volcano.

Titanomagnetite crystals of three tephra layers of Iz-KT (KTa, KTb, KTc) showed distinct chemical compositions. Particularly, three tephra layers showed different Al contents, suggesting that KTa was correlated to A3 and A4, KTb was correlated to A2, and KTc was correlated to A1. Because A1-A8 tephras are covering the pyroclastic flow deposits and lavas of Kosha Volcano, this result suggests the age of the activities of Kosha Volcano is to be

guessed to be elder than the production of KTc, which considered to be supplied around 160 ka according to Suzuki (2001).

Keywords: Myoko Volcanic Chain, tephrochronology, SEM-EDS, orthopyroxene, titanomagnetite, Quaternary research

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Geologic and petrologic study of the Kamo monogenetic volcanic field,Southern Kyushu,Japan

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1. Ibaraki Univ., 2. Kagoshima Univ., 3. Massey Univ., 4. IRGM

Kamo monogenetic volcanic field consists of small-volume basaltic volcanoes forming part of the volcanic front of Southern Kyushu that extend to the Southern Island of Japan. These volcanoes include the late Pleistocene Aojiki volcano formed at about ~100ka and two Holocene maar volcanoes, the Sumiyoshiike(SM:0.5km in diameter) and Yonemaru (YM:1.2km in diameter) that erupted at 8.2ka and 8.1ka respectively (Nagaoka 1988, Nagaoka et al.2001, Moriwaki et al,2016). These two maars were formed through phreatomagmatic eruptions during sea level high stand along the northern edge of the Kagoshima graben, where large caldera forming volcanism has been concentrated, leading to the accumulation of widespread dacitic and rhyolitic tephras (Nagaoka 1988).While the volume of erupted basaltic magma in this area is low, they have played a significant role in the evolution of the felsic magmas in the Kagoshima graben (Kimura et al.2015).

Lithostratigraphic studies for these maars have been reported by Moriwaki et al. (1986) and Moriwaki (1992) in which different lithofacies were identified and described. In this study, we present geologic and petrologic examinations of the products in order to understand the mafic magma process with focus on the maar forming eruptions. In addition, we also provide data for the older Aojiki volcano identified in between the two maars.

From our field investigations, most of the pyroclastic sequence from the two maars were stratified and consists of thin beds of volcanic ash, scoriaceous lapilli and bombs. These tephra deposits are generally rich in accidental clasts, made up of brown pumice and laminated silts sediments, especially at the proximal part of the maar crater. The brown pumice clasts are the product of Ito Ignimbrites coming from the Aira caldera that erupted ~29ka covering a vast area around Southern Kyushu (Aramaki, 1984), while laminated silts sediments formally grouped into the Kamo Formation, considered to be the basement rock of the area (Kobayashi et al.2004, Kagawa and Otsuka,2000).

At YM, the lower outcrop consists of alternating thin beds of ash and lapilli of base surge origin with characteristics cross and planar laminated structures.

The upper outcrops for both maars are richer in juvenile pyroclasts especially at SM. The scoria cone of Aojiki volcano, at attitude of 213m, consists of variable pyroclast sizes ranging from ash to bomb and block. Meanwhile, the Aojiki lava found below the cone is characterized by clinkery aa lava surface textures and massive blocky lava structure.

Petrological features of the juvenile pyroclasts from the two maars are variable with common phenocrysts of plagioclase and clinopyroxene and microphenocryst of olivine set within a glassy groundmass of same minerals exhibiting mostly hyalo-ophitic to intersertal textures. Honey comb texture defined by numerous small melt inclusions in plagioclase phenocrysts are common in the YM products.

Whole rock geochemical data indicates that the juvenile pyroclasts are composed of mostly basalts and

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minor basaltic andesites. All the juvenile pyroclasts can be defined as tholeiitic magma series of mainly medium K characteristic. Distinct chemical trends among the three volcanoes suggest independent magmatic evolution within each volcano. Compositional ranges are narrow for SM (SiO_2 :47.03wt.%-48.01wt.%, MgO: 6.10-6.51 wt.%),Aojiki scoria(SiO_2:50.30 wt.%-50.90 wt.%, MgO: 4.48-4.68 wt.%) and lava(SiO_2:48.06 wt.%-48.81wt.%, MgO: 5.47-5.66wt.%), while a wide compositional range can be recognized in the YM products(from lower to upper). The eruptive products of the upper section (distal products) of the YM are more evolved with SiO_2 content ranging from 51.43 wt.% to 52.10wt.% with low concentration of Ni, Cr, Co compared to the lower and middle products with almost similar concentration of major and trace elements.

Highly Incompatible trace element ratios such as Y versus Zr and Ba versus Y diagrams indicate a distinct correlation line within YM products, which implies fractional crystallization (FC) was not the main magmatic process. While no differences are observed in the SM and Aojiki samples suggesting that these products were formed by FC. REE patterns between the mafic and most evolved samples of YM are remarkably different, while those of SM and Aojiki are almost similar. Mineral chemistry data for core composition of plagioclase phenocrysts for YM is broad showing Anorthite content of 36-90% and 60 -90 % for upper and lower products respectively. These petrologic features of YM products strongly suggests magma mixing process derived from at least two distinct magma sources.

Keywords: monogenetic, maars, Kagoshima graben, basalt, mixing

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Investigation on Lava Tube Caves in Manno lava flow of Mt.Fuji

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[Introduction]
Manno lava flow of Mt.Fuji is a very old lava flow and the eruption is said to be before BC 10000, the silicic acid weight fraction is as low as 49.7% [1)]. Manno lava flow is known to have Manno Fuketsu lava cave (another name is Dainichi Ana lava cave), Yasiki Ana lava cave,Kobou Ana lava cave, Mado Ana lava cave, Ginga Fuketsu lava cave, Kannon Ana lava cave (already buried) [2, 3)]. These are thought to be a series of lava tube cave systems and considered the oldest lava caves in Mt. Fuji. Among them, Mannno Fuketsu lava cave is the longest lava tube cave in Mannno lava flow with a total distance of 908 m in Mannno lava flow [2, 3)]. The yield strength and the surface tension of Manno lava flow were estimated by refering to the Mannno Fuketsu lava cave survey maps [2, 3)] .

[Manano Fuketsu lava tube cave and lava yield strength]
A photograph inside the Manano Fuketsu lava cave (Dainichi Ana lava cave) is shown in Photo 1, and a survey map in the horizontal section and longitudinal section is shown in Fig.1. A cave slope angle $\alpha = 2.5$ ° is obtained from the height difference (30 m) in the longitudinal sectional view and the cave length (700 m). The cave height is approximately 5 m. The lava yield strength f_B is estimated from $f_B = H(\rho g \sin \alpha) / 4$ by the flow limit condition of the Bingham fluid flowing in the inclined circular tube [4)]. When the lava density is 2.5 g / cm ^{3}, $f_B = 1.32 \times 10^4$ dyne / cm ^{2} can be obtained from the above conditions. It is considered to be a reasonable value for basalt lava having a silicic acid weight fraction of 49.7%.

[Lava stalactite and surface tension value]
Many lava stalactite are found in the ceiling of Manno Fuketsu lava cave(Dainichi Ana lava cave). When the lava is drained through the lava tube, the residual molten lava stagnated on the ceiling is hanging down from the ceiling by forming the lava stalactite. The surface tension of lava can be estimated from the pitch of this lava stalactite[5)]. From the stability limit condition of the liquid film adhering to the ceiling, the specific pitch $P = 2\pi (\gamma / g\rho)^{1/2}$ of the wave motion of the liquid film is obtained. Here, γ is the surface tension of the lava, g is the gravitational acceleration, and ρ is the density of the lava. Therefore, we can obtain the surface tension $\gamma = P^2 g\rho / 4\pi^2$ of the lava by measuring the pitch P of the periodic position of the lava stalactite descent from the ceiling [5)]. The pitch measured in the Manno Fuketsu lava cave is roughly P = 3 to 4 cm (see Photo 2), and $\gamma = 560$ to 990 dyne / cm as the surface tension is obtained. The surface tension is considered to be a reasonable value[5)].

[Conclusion]
The yield strength and the surface tension of the Manno lava flow were estimated by the tube shape and internal structure of Manno Fuketsu lava cave(Dainichi Ana lava cave). Both values obtained are considered to be reasonable values for basalt. Yield strength and surface tension are the same as other examples of lava flows of Mt. Fuji [4, 5)]. We are planning to continue to investigate other lava tube cave of Mt. Fuji which has not been studied yet.

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Keywords: Fuji, lava tube, lava flow, lava staractite

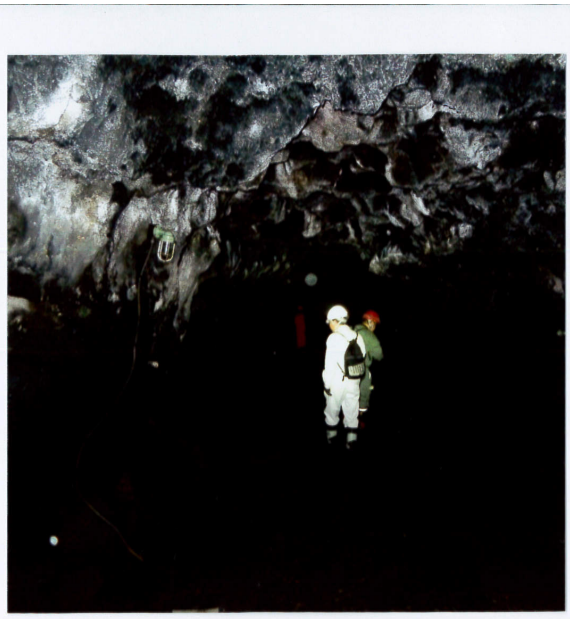

写真１　万野風穴内部

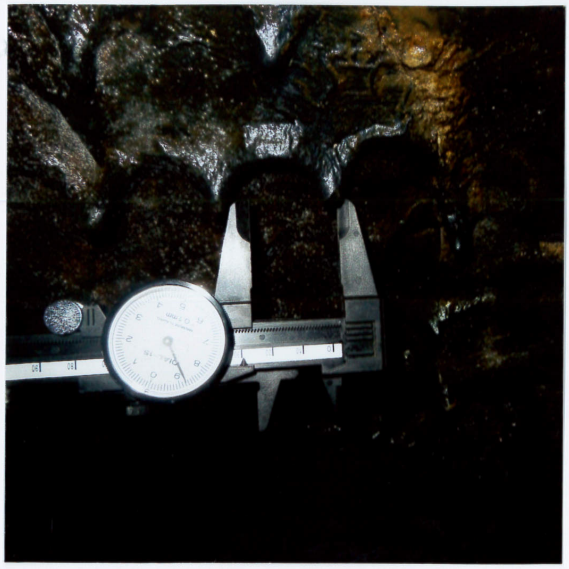

写真２　万野風穴天井の溶岩鍾乳

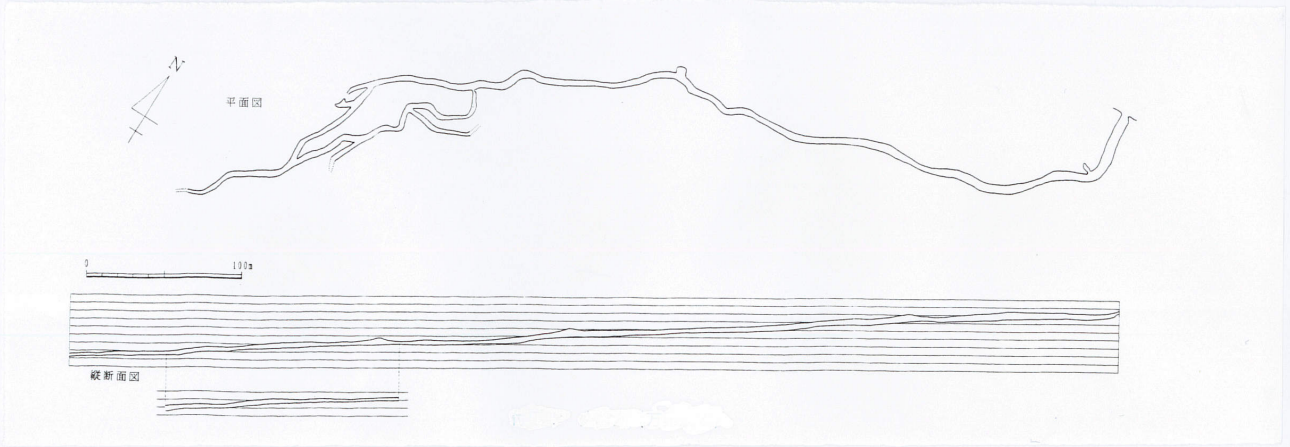

図１　万野風穴の水平及び縦断面図

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[J] Poster | S (Solid Earth Sciences)：S-VC Volcanology

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_31

[S-VC36] Volcanic and igneous activities, and these long-term forecasting

convener:Teruki Oikawa(GSJ, National Institute of Advanced Industrial Science and Technology), Takeshi Hasegawa(Department of Earth Sciences, College of Science, Ibaraki University), Daisuke MIURA(Department of Physical Science, Graduate School of Science, Osaka Prefecture University), Nobuo Geshi(Geological Survey of Japan, The National Institute of Advanced Industrial Science and Technology)

This session focuses on generation and accumulation processes of magmas, magma-crust interaction and degassing, and modes of eruption, long-term forecast of eruption, dispersal and emplacement of the volcanic products. The discussion spans petrological, geochemical, geophysical, and geological processes related with volcanic activity and products in the past, the present and the future.

[SVC36-P01] Reinvestigation of the eruptive history of Me-akan volcano, eastern Hokkaido, using trench survey

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[SVC36-P02] Eruptive history at Ponmachineshiri in Meakan volcano during the last 1000 years: Implication from trench surveys

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[SVC36-P03] Transition of magma plumbing system during the past 14 thousand years of Mashu volcano, eastern Hokkaido

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[SVC36-P04] Eruption sequence of 7.6 ka caldera-forming eruption from Mashu-volcano eastern Hokkaido, japan

*Shibata Shohei[1], Takeshi Hasegawa[1] (1.Department of Earth Sciences, College of Science, Ibarbki University)

[SVC36-P05] Geological study of the 1000 yBP Ma-b eruption, Mashu volcano, eastern Hokkaido: Especially for the change of eruption style.

*Kenta Ueno[1], Mitsuhiro Nakagawa[1] (1.Depatment of Natural History of Sciences, Graduate School of Science, Hokkido University)

[SVC36-P06] Petrology of the caldera-forming eruption of Nigorikawa Caldera, Southwest Hokkaido, Japan

*Yasuaki Kaenda[1], Takeshi Hasegawa[1] (1.University of Ibaraki)

[SVC36-P07] Textual analyses for pumice from precursory Plinian eruption of Aira caldera forming eruption

*Miki Ogata[1], Atsushi Toramaru[2] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu

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[SVC36-P08] Long-term input rate of mafic magma inferred from a long-term heat balance model of silicic magma reservoir

*Shimpei Uesawa[1] (1.Central Research Institute of Electric Power Industry)

[SVC36-P09] Outgassing and Oxidation processes of viscous magmas inferred from micro-Raman and IR spectroscopy

*Kyohei Sano[1], Eiichi Sato[2], Keiji Wada[3], Motohiro Tsuboi[4], Reina NAKAOKA[5] (1.Shirataki-Geopark, 2.Kobe University Institute for Promotion of Higher Education, 3.Hokkaido University of Education at Asahikawa, 4.School of Science and Technology, Kwansei Gakuin University, 5.Kobe Ocean-Bottom Exploration Center, Kobe University)

[SVC36-P10] Distribution of ballistic blocks during the 2014 eruption of Ontake Volcano, central Japan

*Teruki Oikawa[1], Mitsuhiro Yoshimoto[2], Yoshihiro Takeshita[3], Fukashi Maeno[4], Jiro Komori[5], Setsuya Nakada[9], Taketo Shimano[10], Hisashi Sasaki[6], Kishimoto Hiroshi[6], Tatsuro Chiba[6], Yasuhiro Ishimine[7], Kae Tsunematsu[8], Yoshihiro Ishizuka[1] (1.GSJ, National Institute of Advanced Industrial Science and Technology , 2.Mt. Fuji Reserch Institute, Yamanashi Prifectural Goverment, 3.Faculty of Education, Shinshu University, 4.Earthquake Reserch Institute, University of Tokyo, 5.Teikyo Heisei University, 6.Asia Air Survey Co., Ltd., 7.Reserch and Education Center for Natural Hazards, Kagoshima University, 8.Yamagata University, 9.National Reserch Insitute for Earth Science and Disaster Resilience, 10.Graduate School of Environment and Disaearch, Tokoha University)

[SVC36-P11] After 2014 eruption, The volcanic crustal deformation around Mt. Ontake

*Haruno Koike[1], Takeo Ito[2], Kenjiro Matsuhiro[2], Shinichiro Horikawa[2], Takashi OKUDA[2], Takahiro Kunitomo[2], kazushi tanoue[2], Yuto Iwase[1], Koki Kumagai[1] (1.Graduate School of Environmental Studies, Nagoya University, 2.Earthquake and Volcano Research Center, Graduate School of Environmental Studies, Nagoya University)

[SVC36-P12] Geological and petrological study of Kariba volcanic group: Elucidation of the volcanic history and changes of magma

*Shota Taji[1], Mitsuhiro Nakagawa[2] (1.Graduate School of Science, Hokkaido University, 2.Faculty of Science, Hokkaido University)

[SVC36-P13] Stratigraphy and evolutionary mechanism for the low-K tholeiitic magmas at Kotakakura volcano in the Sengan geothermal field, Northeast Japan arc

*Goto Yoshiaki[1], Akihiko Fujinawa[2] (1.Graduate school of Science and Engineering, Ibaraki University, 2.Faculty of Science, Ibaraki University)

[SVC36-P14] Pre-eruptive magmatic processes of upper part of Goshikidake pyroclastic rocks, Zao volcano

*Motohiro Sato[1], Masao Ban[1] (1.Graduate School of Science and Technology, Yamagata University)

[SVC36-P15] Geology and petrology of Futamata volcano, Nasu volcano group, NE Japan

*Shota Watanabe[1], Takeshi Hasegawa[1] (1.Ibaraki Univ.)

[SVC36-P16] Magma of the Haruna-Caldera forming eruption in view of Shirakawa pyroclastic flow deposits-

*Goro Kitani[1], Yuki Suzuki[2], Masayuki Oishi[3] (1.Department of Earth Sciences, School of Education , Waseda University, 2.Department of Earth Sciences, Faculty of Education and Integrated Arts of Sciences, Waseda University, 3.Sendai Regional Headquarters, Japan Meteorological Agency)

[SVC36-P17] Magma plumbing system in the caldera-forming eruption of Haruna volcano indicated by Satomi pyroclastic flow deposit

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[SVC36-P18] Petrology of the Minamiryu-ga-banba in Hakusan Volcano

*Taichiro Miyashita[1], Susumu Umino[1], Yuzuki Ibaraki[2] (1.Kanazawa University, 2.Chuken Consultant Co., Ltd)

[SVC36-P19] Tephrochronological relations of Middle-Pleistocene tephra derived from Myoko Volcanic Group and the pumice and scoria fall deposits found in Kosha Volcano, Central Japan

*Naoaki TAKASUGI[1], Takeshi Saito[1], Kuniaki Makino[1], Takehiko Suzuki[2] (1.Shinshu University, 2.Tokyo Metropolitan University)

[SVC36-P20] Geologic and petrologic study of the Kamo monogenetic volcanic field,Southern Kyushu,Japan

*Linus Anye Nche[1], Takeshi - Hasegawa[1], Tetsuo - Kobayashi[2], Károly - Németh[3], Festus Tongwa Aka[4] (1. Ibaraki Univ., 2.Kagoshima Univ., 3. Massey Univ., 4.IRGM)

[SVC36-P21] **Investigation on Lava Tube Caves in Manno lava flow of Mt.Fuji**

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Reinvestigation of the eruptive history of Me-akan volcano, eastern Hokkaido, using trench survey

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Me-akan volcano is an active volcano located in the Akan Volcano area in the eastern part of Hokkaido. It is located on the southwest wall of the Akan Caldera as one of the caldera volcanoes after the Akan caldera (Furebetsu, Fuppushi, O-akan, and Me-akan) grown. It is believed that the eruption activity of Me-akan volcano started from tens of thousands of years, after which it repeatedly erupted from at least eight craters and reached the present appearance.

The eruptive history of Me-akan volcano after 12000 years ago is shown by Wada et al. (1997). They presented the three pyroclastic flows (Nakamachineshiri I: about 12000 years ago, Nakamachineshiri II: about 9000 years ago, and Nakamachineshiri III: about 5000 to 6000 years ago) with the Nakamachineshiri crater. Among them, the Nakamachineshiri I, 12000 years ago, is the largest, and it has been revealed that it flowed out in all directions from the crater. The Nakamachineshiri II and III are confirmed only at the western foot of the Me-akan volcano. For several thousand years ago, the activities such as flowing out lavas and descending pyroclasts occurred in each mountain body of Ponmachineshiri, Kitayama, Nishiyama and Akanfuji. Since about 1000 years ago, eruption activity has been intermittently occurring in Ponmachineshiri.

We have been conducting a trench survey since 2018, in order to clarify the eruption history of Me-akan volcano since 12000 years ago. In 2018, we conducted a trench survey of nine points at the eastern foot of the Me-akan volcano. In this study, we carried out reinvestigation of the eruption history of Me-akan volcano using the trench survey and the ^{14}C ages, and reported the results.

In the trench survey, the pyroclastic flow deposit was confirmed at the lowest position. From the characteristics of deposit and the age value of 12000 ±40 yrBP (13991calBP-13745calBP) from the carbonized wood contained in the deposit, this pyroclastic flow deposit can be compared with Nakamachineshiri I (Wada et al., 1997). Several pyroclastic surge deposit could be confirmed on the pyroclastic flow deposit through the soil. 6410 ±30 yrBP (7420calBP-7277calBP (95.4%)) from the soil immediately under the lowest pyroclastic surge deposit, and 2710 ±20 yrBP (2855calBP-2761calBP (95.4%)) from the soil directly above the uppermost pyroclastic surge deposit. The age value of the lower pyroclastic surge deposit is comparable to Nakamachineshiri III (Wada et al., 1997). Therefore, Nakamachineshiri III may be distributed not only at the foot of western foot but also at the eastern foot as a pyroclastic surge. In addition, the Nakamachineshiri III not only occurred at about 6000 years ago, but also the possibility of having flowed out several times as a pyroclastic surge by 2800 years ago. At the top of the pyroclastic surge deposit, there were at least 13 scoria fall deposits of Akanfuji. They were sandwiched between volcanic ash soils of several mm to several cm. The age value of 2430 ±20 yrBP (2694calBP-2635calBP (16.7%), 2614calBP-2593calBP (4.7%), 2502calBP-2355calBP (74.0%)) was obtained from the soil directly beneath the lowest deposit of Akanfuji. Therefore, the activity of Akanfuji began around 2700 years ago. This result is consistent with the age of activity of Akanfuji indicated by

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Sato and Wada (2017). At the top of the deposit of Akanfuji, there were three volcanic ashes derived from the Ponmachineshiri through thin soil. The lowest volcanic ash layer (Pon-1, Minami et al., 2019) contains wide spread volcanic ash (Ma-b: about 1000 years ago) from Mashu volcano in patch shape. Therefore, the activities of Akanfuji have been completed about 1,000 years ago, and about 1,000 years ago erupted simultaneously at Ponmachineshiri and Mashu volcano.

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Keywords: Me-akan volcano, Eruption history, Trench survey

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Eruptive history at Ponmachineshiri in Meakan volcano during the last 1000 years: Implication from trench surveys

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Eruptive histories established solely by geological records around the near-vent area are always incomplete, because the preservation potential of the volcanic deposits vary according to local conditions such as altitude, climate, and geomorphology. On the contrary, the static flank of a volcano can have a high potential for preserving volcanic deposits. Undertaking an excavation survey at a static flank, therefore, is critical to observe a more complete depositional sequence of volcanic products in order to establish the eruptive history of an active volcano.

This study focuses on volcanic activities at Ponmachineshiri in Meakan volcano during the last 1000 years. At least four layers of fall deposits were observed at outcrops in the summit area and five excavation sites on the volcanic flank. In chronological order, the fall deposits consist of Pon-1, Pon-2, Pon-3, and Pon-4.

The deposit of the Pon-1 is yellowish brown to dark brown tuff breccia in the summit area (< 15 m thick) and lapilli tuff on the flank (8 cm thick). The deposit is characterized by the presence of abundant breadcrust bombs. The component analysis in the matrix of the deposit (250 –600 μm) revealed that the deposit consists of fresh scoria (50 vol.%) and altered lithic fragments (40 vol.%) with a miner amount of free crystals (10 vol. %). Lenticular or patch-like intercalation of Ma-b (ca. 10th century AD) was observed at the basal part of the deposit.

The Pon-2 deposit is 3.5m thick in the summit area and less than 4 cm on the flank. The deposit consists of scoria (50 vol.%) and altered fragments (40 vol.%) with a miner amount of free crystals (10 vol.%). The deposit shows reddish brown tuff breccia or lapilli tuff facies in the field. The radiocarbon ages of paleosol layers immediately underlying the Pon-2 are 710±20 yrBP and 670±20 yrBP and indicate that the eruption age of the Pon-2 is 13^{th}-14^{th} century AD.

The Pon-3 deposit is yellowish brown lapilli tuff consisting of abundant hydrothermally altered fragments (90 vol.%) with minor amounts of scoria (3 vol.%), gray-pumice (2 vol.%), and free crystals (5 vol.%). The thickness of the deposit is 2 m in the summit area and 6 cm on the flank. The radiocarbon age of a paleosol layer immediately underlying the Pon-2 is 380±20 yrBP, which indicates that eruption of the Pon-3 occurred at 16^{th}-17^{th} century AD.

The deposit of the Pon-4 is blueish gray lapilli tuff. The thickness of the deposit in the summit area is 0.5 m and 3 cm on the flank. The deposit is characterized by the features of containing abundant hydrothermally altered fragments (92 vol.%) with minor amounts of accidental lithic fragments (2 vol.%) and free crystals (6 vol. %). The Pon-4 deposit overlies Ko-c2 (AD1694) and Ta-a (AD1739), thus suggesting that the eruption occurred after AD1739.

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Excavation surveys at the volcanic flank revealed that at least four eruptions occurred at Ponmachineshiri in Meakan volcano during the last 1000 years: namely Pos-1 at ca. 10^{th} century AD; Pon-2 at 13^{th}-14^{th} century AD; Pon-3 at 16^{th}-17^{th} century AD; and Pon-4 after AD1739. The products of these eruptions were preserved as geological units. Thus, these eruptions were relatively large-scale eruptions compared with other historical eruptions which have been eroded already. Coexistence of hydrothermally altered materials and magmatic materials such as scoria in the Pon-1, Pon-2, and Pon-3 indicates that these deposits were sourced from phreatomagmatic eruptions. On the contrary, the absence of magmatic fragments in the Pon-4 deposit suggest that the eruption was phreatic event.

This work was supported by MEXT "Integrated Program for Next Generation Volcano Research and Human Resource Development.

Keywords: Meakan volcano, phreatomagmatic eruption, phreatic eruption

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Transition of magma plumbing system during the past 14 thousand years of Mashu volcano, eastern Hokkaido

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Mashu volcano is characterized by repeated explosive eruptions during 35 thousand years, and formed a caldera (6 x 7 km diameter) by successive plinian eruptions and following a large-scale pyroclastic flows at about 7500 years ago (Katsui et al., 1975;1986; Sumita, 1990; Hasegawa et al., 2009; Kishimoto et al., 2009). This study focus on the transition of the magma plumbing system during the past 14 thousand years from caldera formation stage to post-caldera stage.

Inferred from the cumulative change of the magmatic ejection volume of the Mashu volcano over the past 14000 years, three large-scale eruption events occurred at intervals of about 7000 years: Ma-l at 14000 years ago, caldera-formation of Ma-f, g, h, i, and j). After the formation of the caldera, the lava effusion and the explosive eruptions were repetitiously occurred every few hundreds of years to decades. After the formation of the Kamuinupuri central cone about 4000 years ago, intermittent eruption of Ma-c tephras occurred after the longest dormancy period (about 1500 years) in the post-caldera stage. Currently it has been 1000 years since the latest eruption (Ma-b) of 1000 years ago. Considering the characteristics of the eruption history through the post-caldera stage, it may be the time when the magma accumulation is ready and a new eruption event begins.

In the caldera-formation period, the possibility of simultaneous eruptions from several magma chambers was pointed out from the change of the lithic type and the change of phenocryst composition (Wada et al., 2017). In the TiO_2 vs. K_2O diagram of bulk rock composition, the magmas that caused the caldera formation is different from the post-caldera stage and the Ma-l period magmas, suggesting that the magma plumbing system was different only in caldera-forming period.

Estimated from the MELTS program and the mineral thermometers, the silicic magma chambers of Mashu volcano where phenocrysts (plagioclase-pyroxenes-iron oxides) can co-exist in equilibrium is 4-5 kb in pressure, 4-5% H_2O, temperature of 930 ℃ to 970 ℃ are most suitable, which may have not changed significantly during the past 14000 years.

Keywords: Mashu caldera, magma plumbing system, magma chamber

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Eruption sequence of 7.6 ka caldera-forming eruption from Mashu-volcano eastern Hokkaido, japan

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Mashu volcano is located on eastern Hokkaido, Japan. The volcano has a 7.5 km x 5.5 km caldera in the summi. This caldera was formed by explosive eruption at 7.6 ka (Kishimoto et al.,2009; Yamamoto et al.,2010). In the previous geological study, caldera-forming eruption deposits were described as preceding pyroclastic fall deposits Ma-j to Ma-g and pyroclastic flow deposit Ma-f (Katsui et al.1975). Kishimoto et al. (2009) resulted that Mashu caldera-forming eruption consists of initial Phreatomagmatic eruption (Ma-j), followed by Plinian falls (Ma-i~Ma-g), and a catastrophic pyroclastic flow (Ma-f). After that, Hasegawa et al.(2017) subdivided Ma-f into 7 layers (Ma-f1 to Ma-f7 in descending order) suggesting of more complex eruption sequence of Mashu caldera. In this study, we carried out geological survey, grain size analysis and components analysis (for 2~32 mm size grains) to reveal detailed eruption sequence of Mashu caldera.

Ma-f6 and Ma-f7 are pyroclastic density current deposits (PDC), and rich in gray/banded pumice(40~60 wt%,5~21 wt%, respectively).Median (MdΦ) for Ma-f6 and Ma-f7 are -1.00Φ to 0.89Φ.Ma-f5 (pyroclastic fall deposit) and Ma-f4 (PDC) contain a large amount of accretionary lapilli(each 89wt%,82wt%,respectively).Pumice and lithic fragments are coated by silt size ash. MdΦ for Ma-f4 is -0.55Φ to 3.22Φ, that is finer than Ma-f6 and Ma-f7. Ma-f3 is clast supported PDC containing large amount (>90wt%) of lithic fragments. Lithic fragments are composed of dominant dacite, and minor amount of plutonic and altered rock fragments. MdΦ for Ma-f3 is -3.47Φ to -1.37Φ indicating of lack for very fine sand and silt particles. Ma-f2 is PDC often showing cross lamination. Ma-f2 contains a lot of granule sized lithic fragments (70wt%) and pumice (30wt%). MdΦ for Ma-f2 is -1.84Φ to 1.16Φ . Ma-f1 is the brown ash layer, containing pumice (52wt%) and lithic fragments (48wt%). Boundary between Ma-f1 and Ma-f2 is obscure and grain size gradually decrease to the top. MdΦ for Ma-f1 is -1.22Φ to 1.80Φ. Ma-f1 and f2 can be observed above Ma-f3 without exception.

Based on the data, Ma-f1 to Ma-f7 can be grouped as Ma-f7~Ma-f6, Ma-f5~Ma-f4, Ma-f3~Ma-f1 with different eruption styles. Dominant juveniles change from white pumice to banded/gray pumice from Ma-i to Ma-g in ascending order. Componentry of Ma-f7 and Ma-f6 are consistent with the change of those of underlying Ma-i~g suggesting that Ma-i~Ma-6 are sequential products from single Plinian column. Ma-f5 and Ma-f4 show the characteristics of Phreatomagmatic eruption style. After the collapse of Plinian column to generate PDC of Ma-f6 and Ma-f7, the water/magma ratio might be increased and resulted in change in the eruption style. Volume of lithic fragments drastically increase in Ma-f3~1 that infer caldera collapsed occurred in this phase. Lithofacies of Ma-f3 to Ma-f1 correspond to Layer 1~Layer 3 (Wilson,1985) that are typical sequence formed by fluidal, high-energy PDC. In conclusion, caldera-forming eruption sequence of Mashu volcano could not be from single Plinian column but consist of diverse styles of distinct phases as first Plinian, second Phreatomagmatic and final caldera collapse events.

Keywords: tephra, caldera, Phreatomagmatic-eruption, eruption-sepuence

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Geological study of the 1000 yBP Ma-b eruption, Mashu volcano, eastern Hokkaido: Especially for the change of eruption style.

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Mashu volcano is located at the southeastern rim of Kutcharo caldera in eastern Hokkaido, Japan. Mashu volcano began to erupt 35000 yBP (Hasegawa *et al.*, 2009) and the eruptive history of recent 14000 years has been divided into three stages: stratovolcano building stage, caldera-forming stage and central cone building stage (Katsui *et al.*, 1975). Ma-b eruption of 1000 yBP is the largest eruption (VEI=5of) central cone building stage. Ma-b tephra has been divided into six sub unit: Ma-b1~Ma-b6 (Katsui, 1962; Kishimoto *et al.*, 2009), details of its eruption style, eruption sequence and change of magma are not clear. Eruption sequence of Ma-b eruption was reconsidered by geological survey, grain size analysis, component analysis and whole-rock chemical composition analysis.

Based on facies and component ratios, we divided Ma-b tephra into six sub units; Ma-b1 to Ma-b6 in descending order as Kishimoto *et al.* (2009). Ma-b6, the lowest unit of Ma-b tephra, is thin gray-brown ash deposits consisting of pumice, crystals and lithics of sand size. We found it only in one section of northern area of Mashu volcano. Ma-b5 is well-sorted, clast-supported yellowish-white pumice fall deposits. This unit is the largest scale among Ma-b tephra, and distributed in wide area of northern Mashu. Ma-b4 is alteration of comparatively well-sorted ash layer and poorly-sorted lapilli tuff layer with pumice scattered in ashy matrix. Ma-b4 usually contains accretionary lapilli. The lower part of Ma-b4 shows cross-laminated structure, and ratio of pumice increases in the upper part. Then, we consider that Ma-b4 consists of pyroclastic surge and ash fall deposits. Ma-b3 is yellowish-white pumice fall deposits and distributed in the WSW area of Mashu. Ma-b2 is a pyroclastic surge deposit, consisting of pumice and lithics scattered in gray-brown ash deposits, and contains lots of accretionary lapilli. Ma-b1 is a poorly-sorted pumice fall deposit distributed in WSW area. The layer consists of pumice coated by silt size ash, suggesting that it would be supplied from wet column. Juvenile materials of Ma-b tephra are composed of vesiculated pumice and blocky to flaky, blue-gray to black lithic fragments. Matrix of these lithic fragments is fresh and glassy, containing very small bubbles in it. In addition, there also exist small amount of altered lithic fragments. As for juvenile materials, ratios of pumice in Ma-b6, Ma-b5 and Ma-b3 are more than 90%, but Ma-b4 and Ma-b2 contains >70% lithic fragments. On the other hand, Ma-b1 consists of ca. 70% pumice and ca. 20% lithic fragments. These juvenile materials are pyroxene dacite (SiO_2=67.3~69.7% and K_2O=0.6~0.7%), and SiO_2 contents decrease ca. 1% from Ma-b5 to Ma-b1.

From changes of facies of each unit, we considered the eruption sequence of Ma-b as follows. Detail of Ma-b6 is not clear because it distributes in limited area, it is considered that Ma-b6 would be started with small explosion. Ma-b5 is a plinian eruption and discharged pumice fall deposits. This eruption is the largest one through Ma-b. Considering that thickness and grain size become thinner and smaller, the eruption scale of the following eruptions abruptly decrease. Eruption style of Ma-b4 changes to phreatomagmatic eruption by interaction of magma and external water. Flaky texture (Wohletz, 1983) and small bubbles of lithic fragments are consistent with it. Ma-b3 is pumice fall deposits from plinian eruption, but changed to phreatomagmatic again in Ma-b2. Ma-b1 is considered as phreatoplinian eruption and erupted pumice fall deposits coated by ash.

Ma-b eruption repeated phreatomagmatic eruption, suggesting that aquifer may exist under Kamuinupuri

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volcano. Transition of eruption style should be determined by interaction of uprising magma and external water. Eruption rate of Ma-b is the maximum in initial stage, and then phreatomagmatic eruptions frequently occur as decreasing eruption rate.

Keywords: Mashu volcano, tephrostratigraphy, phreatomagmatic eruption, active volcano

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Petrology of the caldera-forming eruption of Nigorikawa Caldera, Southwest Hokkaido, Japan

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The Nigorikawa volcano, which has a caldera approximately 3 km in diameter is located in southwest Hokkaido, Japan. Nigorikawa caldera was formed by ca. 12 ka explosive eruptions. Previous studies by Yanai et al. (1992) suggested that the caldera-forming eruption deposits (Ng) were divided into 4 units: Ng-c, Ng-b, Ng-a fall, Ng-a flow, in ascending order. The reflective index of volcanic glasses increases from Ng-c (bottom: n = 1.489) to Ng-a (top: n = 1.504) (Yanai et al., 1992). However, there is no systematic geochemical data, such as volcanic glass and whole rock chemistries, for Ng units. In this study, we performed field surveys and sampling and determined petrological features for juvenile clasts of Ng units to reveal the caldera-forming magma plumbing system of this volcano.
Ng can be characterized by containing a large amount of hornblende phenocryst. Ng-c is a cross-bedded, pyroclastic surge deposit, which consists of dominant fine ash and rare pumice clasts. We newly divided Ng-b into lower pyroclastic fall (Ng-b fall) and upper pyroclastic surge deposits (Ng-b surge). Ng-a fall and flow are pyroclastic fall showing reverse grading, massive pyroclastic flow deposits, respectively. Although the distribution of Ng-a flow was reported within 5 km around the caldera (Yanai et al., 1992), we found and described Ng-a flow at several outcrops 15 km far from the source. On Ng-a flow, pyroclastic surge deposit was observed. In this study, we refer to it as Ng-a surge. In addition, another pyroclastic flow deposit (Ng-x) containing hornblende phenocryst was discovered above Ng-a surge with intervening thin soil layer at 4.5 km northest from the source. Consistent chemical composition with other Ng units suggests Ng-x was derived from Nigorikawa caldera.
These geological data infer that eruption volume and duration of Nigorikawa caldera-forming eruption could be larger and longer than previously reported, respectively. Juvenile clasts of Ng can be classified into three types: white pumice (WP), gray pumice (GP), banded pumice (BP). We recognized all type of juvenile clasts in all units, and the dominant component is WP. There is no enough petrological data of Ng-c obtained because of fine lithofacies. The phenocryst assemblage of WP is Pl + Hb ±Cpx ±Opx ±Opq ±Qtz, and with hyalopilitic texture. Petrography of GP is almost the same as WP, except for the absent of Qtz, and a groundmass texture of GP is hyaloophitic. In the Harker diagrams, almost of WP (SiO_2 = 61.2 - 63.7 wt.%) and GP(SiO_2 = 54.6 - 57.4 wt.%) plot on a single linear trend, and BP plots between WP and GP. Systematic vertical change of chemical compositions inferred by Yanai et al., (1992) could not be recognized. GP of Ng-b is the most mafic and show a distinct trend from main linear trend, especially in Na_2O-SiO_2, Ba-SiO_2, Zr-SiO_2 diagrams. The volcanic glass composition of WP and white part of BP show common composition as SiO_2 = 71.2 - 78.2 wt.%. Chemical trends of volcanic glass are almost similar to those of whole rock composition. The heterogeneous texture of BP and the existence of three types of juvenile clasts in all units indicate mixing and mingling of different types of magma are main processes in Nigorikawa caldera-forming eruption. Chemical trend converges to felsic side (at SiO_2 = 61.2 - 63.7 wt.%) suggesting single felsic end member magma. On the other hand, two distinct trends for GPs of Ng-b and Ng-a imply that at least two different mafic end member magmas had existed. Magma plumbing system of Nigorikawa caldera-forming eruption might be composed of shallower and larger felsic magma, producing white pumice, and two mafic magmas that successively injected into the felsic magma at different phases.

Keywords: Nigorikawa caldera , Petrology

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Textual analyses for pumice from precursory Plinian eruption of Aira caldera forming eruption

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Aira caldera is located in northern part of Kagoshima bay, southern Kyushu. The caldera forming eruption (29,000 BP) produced Osumi pumice fall (+Tarumizu pyroclastic flow), Tsumaya pyroclastic flow, Kamewarizaka breccia, and Ito pyroclastic flow (+ AT ash). In this study, we focus on bubbles in the ejecta because the vesiculation of magma is a driving force of magma ascent and it is expected that vesicular textures reflect the condition in the magma chamber and in the conduit. The aim of this study is to quantitatively describe the vesicle textures in Osumi pumice fall from Aira caldera forming eruption.
We sampled Osumi pumice fall in Tarumizu, Kagoshima, where the deposits are inclined to the ground, showing a typical mantle bedding structure. Samples were basically taken horizontally by intervals of 50 cm from the lower boundary to the welded part of Ata pyroclastic flow in the total horizontal length of the deposits of 850 cm (totally 18 layers), separately for characteristic two fine grain-rich thin layers (fine 1 and fine 2). Near the upper boundary to the Tarumizu pyroclastic flow, samples were taken vertically by intervals of 30 cm (3 layers).
We selected 8 layers by the equal interval (0 cm, 150 cm, fine1, 300 cm, 450 cm, 600 cm, fine2, 750 cm, +30 cm and +90 cm) and two fine-rich layers for the analysis of grain size distribution by using sieves(-5≦Φ≦1). For bulk density measurements, we selected ten pumices with size range 8~16 mm for each layer (4 pumices for fine 1). The bulk density measurements were conducted by using 3D laser scanner DAVID (3D model construction software) and Hira 3D viewer (calculation software of bulk volume). For the textual analysis, we made 8 chips (each chip includes 2 pumices (maximum and minimum bulk densities)) for 8 layers. We observed vesicle textures by SEM (HITACHI TM3030Plus:15keV). After image processing, we conducted vesicle textual analyses and phenocrysts area measurements by imageJ software.
The bulk density of 10 layers ranges from 0.46 to 1.18 g/cm^3 (maximum difference of 0.6 g/cm^3 at 300 cm layer, minimum difference of 0.2 g/cm^3 at fine 2 layer). We define a bubble with an area of 0.01 mm^2 or more as a pheno-bubble and a bubble with an area less than 0.01 mm^2 as a matrix-bubble.
Matrix-bubbles had three characteristic textures: 1. Single spherical bubbles, 2. Elongated bubbles, 3. Connected bubbles. The vesicularity of 8 layers ranges from 64.8 to 92.7 %. There is a correlation between pheno-bubble abundance and bulk density but no correlation between amount of phenocrysts and bulk density.
The presence of elongated bubbles indicates that bubbles experience a sort of deformation. Connected bubbles in small scale suggest that pheno-bubbles increase their sizes by the coalescence process of bubbles. The correlation between pheno-bubble abundance and bulk density suggests that bulk density is determined by pheno-bubbles. The differences in bulk density in one layer can be thought to result from the differences in pheno-bubble abundance. If pheno-bubbles are the relic of bubbles in the magma chamber before eruption, it is expected that pheno-bubbles heterogeneously distribute by spatial scales of several millimeters in the magma chamber, which triggered the eruption.

Keywords: caldera, vesicularity, pheno-bubble

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Long-term input rate of mafic magma inferred from a long-term heat balance model of silicic magma reservoir

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A model, which represents a formation dynamics of eruptible silicic magma reservoir made from partially melted crystal rich mush in the upper crust generated by inputs of mafic magmas supplied from mafic magma reservoirs accumulated in the lower crust, is beeing generalized (e.g. Sparks et al., 2019). According to this model, it is likely that an eruption of felsic magma is caused by inputs of mafic magmas. Knowing the input rate of mafic magma is, therefore, important not only for an understanding the magma dynamics but also for a long-term evaluation of eruption possibility. Koyaguchi and Kaneko (2000) proposed the concept, and discussed the development process of the silicic maga subdivided into two stages: the stage of rapid rise in the temperature, partial melting, disturbance, rapid cooling of the felsic magma due to the input of mafic magma (Convection & Melting (C & M) mode), and the subsequent conductive cooling stage (Conductive Cooling (CC) mode). In this paper, I would like to suggest that we may be able to estimate a long-term mafic magma input rate using an improved model of long-term heat balance of the CC stage if a magma reservoir size is obtained underneath the volcano with known eruption rate during the past thousands of years observed by the geological study.

The basic formulas of the model are following equations:
$\Delta Q = I\rho\{cT_b + L(1 - \phi_{crit})\} - E\rho cT_{eft}$, (1)
$Q_{loss} = 2\pi\{a + b(tanh^{-1}e/e)\}k(T_{eft} - T_{wrt})$. (2)
Here, ΔQ is the difference between the power of the erupted magma (E: long-term eruption rate; km^3/kyr) and that of the input magma (I: long term input rate; km^3/kyr), and Q_{loss} is the power dissipation of the oblate spheroid shape magma reservoir. a is a major axis of the spheroid, b is its minor axis, and e is the eccentricity. ρ is the density of the rock, c is the specific heat of the rock, L is the latent heat of fusion, k is the thermal conductivity, ϕ_{crit} is the melt fraction of the eruptable magma, T_b is the temperature of the mafic magma, T_{eft} is the effective temperature of eruptible magma, T_{wrt} is the crustal temperature around the magma reservoir. Furthermore, assuming that ΔQ can not be completely consumed by Q_{loss}, the residual power Q_{ex} is: $Q_{ex} = \Delta Q - Q_{loss}$ (3) and that of the volume increase rate (R_{ex}; km^3/kyr) is: $R_{ex} = Q_{ex} / \rho cT_{eft}$ (4).

Next, I conducted to calculate the supply rate of mafic magma by assuming concrete cases using this model. For example, if a = 3600 m was observed underneath a volcano which was geologically obtained the long-term eruption rate of 0.1 (km^3/kyr), the magma input rate for maintaining the magma reservoir size (Q_{ex} = 0) was calculated to be 0.5 (km^3/kyr), assuming that T_{wrt} = 100 ˚C, the flatness ratio of the magma reservoir was 0.7 (1-b/a) and other parameters were refferred to Koyaguchi and Kaneko (2000). This model, however, has a large dependency on T_{wrt}. For example, if the same injection and input rate were assumed as above instance, it balanced at a = ~ 20 km when T_{wrt} = 500 ˚C. With this model, although there is a large temperature dependence of the surrounding crust, it could be shown that the long-term input rate of mafic magma during the past thousands of years can be estimated by knowing the present size of the magma reservoir underneath the volcano with the known eruption rate.

Keywords: heat balance model, long-term eruption rate , long-term magma input rate, size of magma reservoir

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Outgassing and Oxidation processes of viscous magmas inferred from micro-Raman and IR spectroscopy

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Silicic volcanism ranges from explosive to effusive. Understanding what controls in such activity is an important issue to explain the explosive-effusive transition. The recent observation on Cordon Caulle (Chile, 2011-12) reported the explosive-effusive hybrid activity (Schipper et al., 2013), and we can consider that this eruption style reflects heterogeneous processes such as vesiculation and outgassing in volcanic conduit. Obsidian can be observed as pyroclastic and effusive-lava products of such a silicic and viscous magma eruption, and we can consider that obsidian contains the heterogeneities in rock textures such as crystallinity, water concentration oxidation state, and structure of glass networks. Thus, we performed the micro-Raman and IR spectroscopy on obsidian in order to discuss the heterogeneous processes recorded in rock texture.
At the Akaishiyama obsidian lava on Shirataki, northern Hokkaido, Japan, we can observe the red-colored oxidized obsidian mingled with black-colored obsidian. The mingled obsidian shows various contrasts and distributions on the hand specimen, and we can consider that such various oxidation texture reflects the different mechanisms of outgassing and oxidation during the eruption. In this study, we used the microRaman and IR spectroscopy to characterize the oxidation state in the obsidian. We obtained the 2 types of Raman spectra of oxide microlites in red and black obsidians, respectively. Compared with referential spectra, we identified the captured spectrum as magnetite and hematite. Furthermore, the height of 470 cm^{-1} on the glassy part shows the degrees of oxidation. The IR spectroscopy shows the different water concentration between red-colored and black-colored obsidian glasses. The red-colored oxidized glass shows lower water concentration than black-colored obsidian glasses. Based on the analytical results of microRaman and IR spectroscopy and, we discuss the formation process of heterogeneous oxidation textures during the eruption.

Keywords: Oxidation texture, Raman spectroscopy, IR spectroscopy, obsidian

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Distribution of ballistic blocks during the 2014 eruption of Ontake Volcano, central Japan

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The 2014 eruption of Ontake Volcano, central Japan killed 56 people for ballistic blocks. We entered near the crater after this eruption, investigated the size and distribution density of ballistic blocks. This eruption formed the new craters extending about 0.8 km from the northwest to southeast. From the distribution of ballistic rocks, it became clear that they were released from the new craters located in the Jigokudani. It is within 0.9 km radius from its new craters that these ballistic blocks are distributed high densely (> one/m^2). The area where fatalities occurred from this eruption was consistent with the area where such ballistic blocks fell at high density. The size of the largest ballistic rock is 96 ×70 ×64 cm. It is commonly observed in other phreatic eruptions in the Japanese Islands that ballistic rocks fall at high density within about 1 km from the crater. Therefore, in order to prevent severe damage of ballistic rocks due to phreatic eruption, it is necessary to leave 1 km from the crater.

Keywords: Mt. Ontake, eruption, ejected material, distribution density, damaege, hazard mitigation

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After 2014 eruption, The volcanic crustal deformation around Mt. Ontake

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On September 27, 2014, the Mt. Ontake occurred a phreatic eruption. The eruption made fifty-nine casualties and still five missing persons. Because the phreatic eruption makes a smaller signal than a magmatic eruption, a phreatic eruption is harder to predict than a magmatic eruption. For this reason, understanding of the phreatic eruption is essential for the mitigation of volcanic hazard. The observed crustal deformation of Mt.Ontake detected the inflation of the mountain related to the 2007 small eruption. In actually, the NE-SW baseline, which is crossing the Mt. Ontake (Ochiai Karatani - Ontake Tanohara), extended about 2cm at the 2007 event. During 2007 and 2014, the length of the baseline did not change. After the 2014 event, the baseline is contracting about 1cm/yr. The contracting is continue to 2019, and the length of the baseline reaches before 2007 eruption. Also, detected crustal deformation in 2007 event is more extensive region than the 2014 event. Takagi and Onizawa (2016) make two dikes model from observed crustal deformation in 2007 and for the 2014 event two dikes and a small shadow pressure source model. We point out the effect of topography for the shallow source estimation because Takagi and Onizawa (2016) used GNSS observation sites at the foothills where locate over 4km far from the summit of Mt.Ontake. By the way, we developed new five continuous GNSS sites around the foothills of Mt. Ontake after the 2014 eruption and started 11 campaign GNSS observation near the summit region at 2016. The local GNSS observation revealed narrow deformation, which is about 10cm contraction between about 1 km distance GNSS sites from 2017 to 2018. The GNSS sites locate at within about 1km distance from the 2014 crater of Mt.Ontake. The GNSS observation near the summit is essential because the GNSS result suggests the shallow pressure source. The shallow pressure source estimation is affected by topography. In the presentation, we evaluate the topographic effect of the Mountain using three-dimensional Finite element method (FEM). We present the estimate pressure source under considering a topographic effect.

Keywords: Mt.ontake

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Geological and petrological study of Kariba volcanic group: Elucidation of the volcanic history and changes of magma

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Kariba volcanic group, act in Pleistocene, is situated at the northwestern part of the Oshima Peninsula, southwestern Hokkaido. Volcanic centers of the individual edifice are distributed over the range of about 7 km from north to south and about 10 km from east to west, and present peak is Mt. Kariba, 1520 m height. There are several previous works (Yamagishi and Kurosawa, 1987 and Kaneoka et al., 1987), suggesting that Kariba volcanic group is divided into two edifices; Anatokomae lavas (0.7 Ma) and Karibayama lavas (0.25Ma). Whole-rock compositions were also reported by Nakagawa (1992) and Kosugi et al. (2013). However, volcanic history and petrological characteristics of the Kariba volcanic group have not been discussed. The purpose of the study is to reveal the history of the volcanic edifice and the transition of magma. First, we observed aerial photographs and conducted geological survey (divide each eruptive unit, check geological relationships and degrees of dissection of these units). We also collected samples and determined petrographic features, whole-rock major and trace element compositions and Sr-Nd isotopic ratios. Furthermore, we are analyzing K-Ar ages for 5 samples.

Then, we divided volcanic ejecta of Kariba volcanic group into 12 units according to the estimated eruptive centers and these strata, and these units were sorted into 3 stages by reported K-Ar ages, estimated ages from these strata and degrees of erosion, and petrological characteristics. Stage 1 was a subaqueous activity and lavas flowed down to the westward. Subsequently, activity shifted completely to subaerial condition. The vent positions scattered throughout the edifice during the Stage 2, volcanic centers concentrated into the center of the edifice during the Stage 3. As a result, shield volcano with flat edifice was formed at Kariba volcanic group.

The eruptive rocks are composed of basalt to andesite and are classified as high-K and calk-alkaline series. Mafic inclusions are found in all stages. Negative Nb and Ta anomalies and depleted Sr-Nd isotopic ratio of the rocks are similar to the back-arc volcanoes of northeastern Japan arc, especially to Oshima-Kojima (Kosugi et al., 2013). Petrological characteristics of host rocks are different in each stage. Stage 1 lavas are quartz-biotite-olivine basaltic andesite and their SiO_2 contents concentrate in a narrow range. In addition, Stage1 rocks show high Sr, low Nd isotopic ratios compared to Stage 2 and Stage 3. Stage 2 lavas consist of orthopyroxene-bearing olivine-quartz-amphibole-clinopyroxene-biotite andesite and Stage 3 rocks are orthopyroxene-bearing quartz-clinopyroxene-amphibole-olivine-biotite andesite. Stage 2 and Stage 3 rocks make different trends in many Harker diagrams, and Stage 3 ones are rich in MgO. On the other hand, mafic inclusions have wider compositional range than those of host rocks, and there is no difference among the stages. Existence of mafic inclusions, disequilibrium mineral assemblages such as quartz and olivine, dusty and oscillatory zoning in plagioclase indicate that magma mixing was the main magmatic process. Moreover, different trends of host rocks in each stage indicate that mafic and felsic end-member magmas should be different; Stage1 is basalt and basaltic andesite, Stage 2 and Stage 3 are basalt and andesite but those of Stage 3 are richer in MgO content than those of Stage 2.

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Keywords: Kariba volcanic group, Southwestern Hokkaido, K-Ar dating, whole-rock chemistry, back-arc volcano

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Stratigraphy and evolutionary mechanism for the low-K tholeiitic magmas at Kotakakura volcano in the Sengan geothermal field, Northeast Japan arc

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Background and purpose

Kotakakura volcano is a Quaternary stratovolcano located in the Sengan geothermal field, Northeast Japan arc. It consists of low-K tholeiitic series, and has a K-Ar age of 1.2 to 2.3 Ma (Suto and Ishii, 1987). In order to elucidate the mechanisms that cause the compositional variations of low-K tholeiitic magmas in Northeast Japan arc, geology and stratigraphy along with petrology and petrography on the Kotakakura ejecta are revealed with high resolution. The crystallization differentiation of phenocrysts has been considered as the chi of mechanism to create the characteristic tholeiitic variation trend. It is basically true for the case with the Kotakakura ejecta, either crustal assimilation or mixing of felsic magma has considerable role acted effort in several lava flows in the early stage of development.

Geology

Kotakakura volcano consist mainly of lava flows. On the basis of presumed eruption center deducted from flow directions, the ejecta is roughly divided into Kotakakura East lava group (KTE) and Kotakakura North lava group (KTN). The KTE and KTN are subdivided into 16 and 7 lava flows, on the bases of the topography of the individual lava robe, stratigraphic relations, and lithofacies, as well as petrological features, petrography and bulk chemical compositions. Although we can not confirm the direct covering relationship, we infer that KTN is covered by KTE from the remaining state of the terrain at the boundary. In addition, the KTN suffered weathering erosion of outcrops heavily compared with KTE, so that the KTN is considered to be effused earlier than KTE.

Petrological data

Petrography

The KTE lavas commonly contain Plagioclase, Orthopyroxene, Clinopyroxene, opaque mineral, as phenocryst phases. Olivine are found only in KTE1 to 3. The amount of phenocrysts varies from 16.9 to 48.5.

The KTN lavas commonly contain Plagioclase, Orthopyroxene, Clinopyroxene, Opaque mineral, as phenocryst phases. Phenocryst-sized quartz grains are found only in KTN1, 1'. The amount of phenocrysts varies from 19.8 to 41.5.

Major elements

The SiO2 content varies from 49.1 to 60.9, and almost all the ejecta come within the low-K basalt to andesite clan on the Harker diagram. Both the KTE and KTN lava samples come within the range for the tholeiitic series in the northern subzone of the Nasu (frontal) volcanic zone in the NEJ (Kawano et al., 1961), with slightly high Al2O3 and CaO, and low FeO*, MgO, and Na2O levels compared with the average TH trend in the NEJ.

Almost all the Kotakakura samples are plotted in the area for the tholeiite (TH) series on the Miyashiro's diagram. The exceptional two samples also come low-SiO2 extension of the trend for the Kotakakura TH series. The KTE samples show typical variation trend for the low-K tholeiite series in the Northeast Japan arc (NEJ). The KTN samples, on the other hand, show somewhat peculiar trend; the FeO*/MgO decreases slightly with increasing SiO2.

Trace elements

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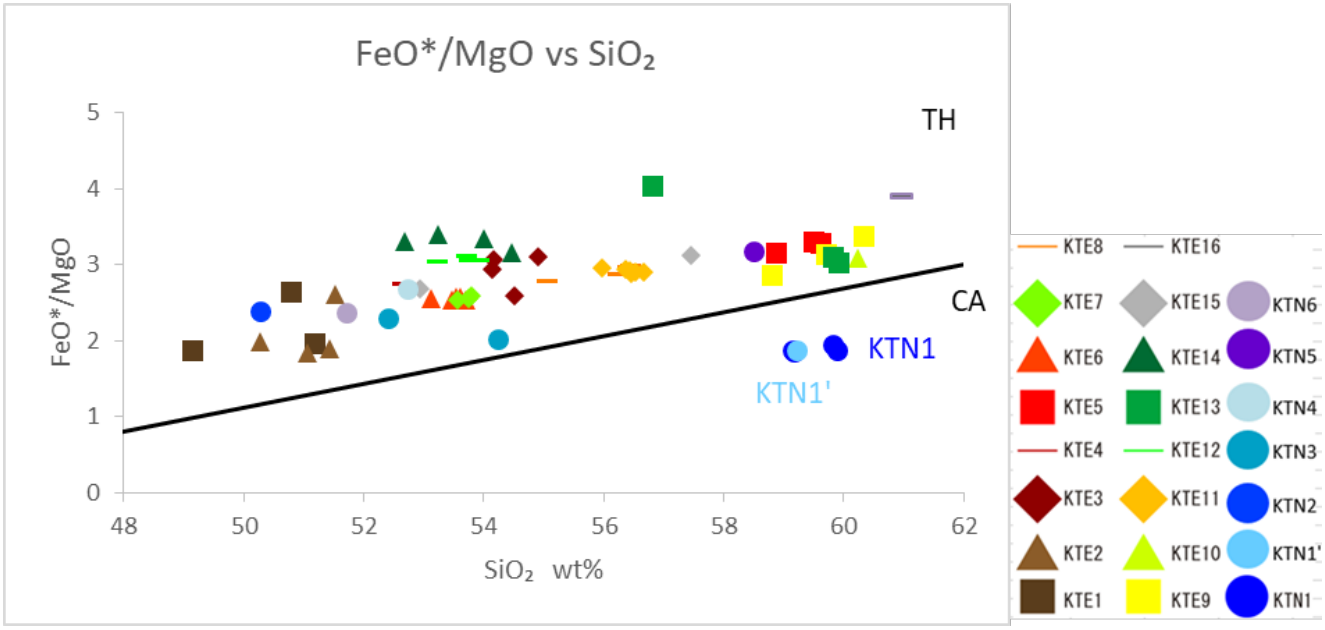
The KTE samples show virtually the same incompatible element characteristics as those typical for the TH in NEJ. The KTN samples basically share the characteristics with the coexisting KTE, but only Y kept almost constant through the whole SiO2 range of the KTN variation.

Discussion

Because the KTE shows the typical tholeiitic variation trend which share the TH series in NEJ, a crystallization differentiation modeling was examined using mass balance calculation by employing phenocrysts as the fractionated phases. The results successfully reproduce the actual variation trends for the KTE. The KTE did not become more evolved composition with descending order of eruption, suggesting that either intermittent supply of primitive tholeiitic magma into the differentiating chamber, or liquid differentiation caused by boundary-layer convection at the chamber wall acted as the additional role in the compositional variation process of the KTE.

As for the KTN peculiar trend, it may be due to incorporation of some quartz-bearing silicic component into the differentiating tholeiitic magma. Such silicic component might be either the Tamagawa dacitic welded tuff that lies under the Kotakakura volcanic edifice, or rhyolitic partial melt of crustal origin.

Keywords: stratigraphy, tholeiitic magmas, crystallization differentiation, magma mixing



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Pre-eruptive magmatic processes of upper part of Goshikidake pyroclastic rocks, Zao volcano

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Zao volcano is the active stratovolcano, which has many eruption records before 1940. Precursory phenomena, such as volcanic tremors and earthquakes, have been detected since 2013. Therefore, it is necessary to examine pre-eruptive magmatic processes to understand the current situation of this volcano. In this study, we revealed pre-eruptive magmatic processes on the Okama crater eruption products from 800 years ago to present, by detailed petrologic examination including kinetic modelling of chemical zoning and thermodynamic approach.

Eruption products are pyroclastic surge deposits with periodically existing bomb concentrated layers. The rock samples are basaltic andesite to andesite, including plagioclase, orthopyroxene, clinopyroxene and magnetite as phenocryst. Olivine with reaction rim of clinopyroxene rarely observed. Rocks are classified into medium-K, calc-alkaline series showing liner trends in Harker diagram. Plagioclase: core are An64-86 (peak value: An68, 74), the rim are An_{60-86} ($An_{64, 70, 76}$), and groundmass are An_{57-80} (An_{63}). Orhopyroxene: core are Mg#=60-75 (Mg#=65), the rim are Mg#=64-76 (overgrouth rim is Mg#=65, Mg rich rim is Mg#=71), and groundmass are Mg#=63-67 (Mg#=64). Clinopyroxene: core are Mg#=64-67, and rim are Mg#=64-76. Magnetite: core are Mg/Mn=7-21 (Mg/Mn=12-14), and rim are Mg/Mn=8-18 (Mg/Mn=11, 15). Plagioclase was classified into four types; C-type: homogeneous core with or without normal zoning (core composition An_{70-80}), P-type: patchy-like heterogeneous/oscillatory zoned core (An_{70-75} and An_{60-66}), D-type: having dusty zone (An_{75-90}) on the rim, H-type: honeycomb core (An_{75-85}) and low An rim (An_{60-65}). Orthopyroxene was classified into four types; L-type: low-Mg (Mg#=60-67) core sometimes having normal zoned rim, R-type: low-Mg core having reverse zoned rim. M-type: small phenocryst with medium Mg core sometimes having normal zoned rim. H-type: heterogeneous core with high (Mg#=70-76) and medium parts. R-type is subdivided into subtype-I: thin high-Mg (Mg#=71-76) rim, subtype-II: medium-Mg and Al (Mg#=69-70) broad rim, and subtype-III: medium-Mg and low-Al broad rim. Estimated temperature for low, medium, and high-Mg parts by two-pyroxene geothermometer are 950-1000℃, 1010-1040℃, and 1030-1060℃.

All rocks were formed by mixing between low temperature and high temperature end-member magmas (LT and HT-magmas). The estimated compositions of end-member magmas by using rhyolite-MELTS algorithm were as follows; LT-magma: SiO_2=48.0-50.0 wt.%, T=953-999℃, P=1.5 kbar, H_2O=1.0-2.0 wt.%, HT-magma: SiO_2=59.0-62.0 wt.%, T=1060-1126℃, P=1.5-2.0 kbar, H_2O=1.0-2.0 wt.%. The stable mixed magma (M-magma) where the rim precipitated would be formed in the chamber. We note the Mg-medium and high rim would be formed from Mg-richer mixed magma which would appear from injection of HT-magma to form M-magma. By comparing observed and calculated zoning profiles, we estimated the residence times of orthopyroxene phenocrysts in the M-magma. We assumed the temperature and oxyegen fugacity conditions are 1025℃ and was NNO-buffer. The initial profile of Mg# for orthopyroxene crystal is drawn based on the zoning profile of Al. The estimated residence times of R-type (I) crystals are 0.5 days to 2 years and those of R-type (II) and (III) crystals are 5 to 20 years. In terms of plagioclase phenocrysts, zoning profiles show that several patterns of correlation between MgO and An in core. These would reflect that the multiple magmatic processes in the mixed magma.

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Keywords: magma plumbing system, residence time, rhyolite-MELTS, chemical zoning, orthopyroxene, Zao volcano

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Geology and petrology of Futamata volcano, Nasu volcano group, NE Japan

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Futamata volcano (FV) composes Nasu stratovolcano group (NSG), NE Japan. The activities of NSG started from Kasshiasahi-dake (540-420ka), and the locus of eruptions shifted to south forming Sanbon-yari-dake (360-270ka), Asahi-dake (170-70ka), Minamigassan (210-80ka) and Chausu-dake (16ka-present). However, FV (140-90ka) was the only unique volcano formed in the northern part of NSG (Ban & Takaoka, 1995; Fujita, 1988; Yamamoto, 1999). In order to reveal the eruption history and magmatic processes, we performed geological and petrological study for Futamata volcano.
Yamamoto (1999) defined an outline of stratigraphy of FV as consisting of Iwayama lava flow, Futamata pyroclastic flow deposit and Futamatayama lava dome in ascending order. In this study, we revised the Iwayama lava flow into 12 units by geomorphology, distribution and mineral assemblages: FLN (north: 3 units), FLW (west: 3 units) and FLS (south: 6 units); Futamata pyroclastic flow deposit can be divided into 2 units: FBW (west) and FBE (east), and Futamatayama lava dome into 2 units: FOD and FMD. We summarized these units into two stages by combining geological and petrological data, such as first lava flow stage (S1) and second lava dome stage (S2). The S1 is composed of FLN, FLW, FLS and FBW. S2 consists of FOD, FMD and FBE.
Mafic inclusions are common in all ejecta of FV, and they often show quenched margins at the boundary with host rocks. The host rocks of S1 are mainly quartz-bearing olivine clinopyroxene orthopyroxene andesite to dacite. On the other hand, host rocks in S2 are clinopyroxene orthopyroxene andesite to dacite, and they sometimes contain hornblende. SiO_2contents of host rocks of S1 and S2 are in the range of 53.5 to 68.4 wt.%. Mafic inclusions of both stages are predominantly olivine clinopyroxene orthopyroxene basalt to basaltic andesite. Their SiO_2contents range from 50.6 to 59.3 wt.%.
Chemical difference between two stages is clearer at mafic inclusions on Miyashiro (FeO*/MgO vs. SiO_2) diagram. Each stage forms a distinctive linear trend subparallel to one another (S1: FeO*/MgO = 1.9; S2: FeO*/MgO = 2.2, at SiO_2= 64.1 wt.%), and mafic samples of S1 and S2 can be categorized as calc-alkaline and tholeiitic series in the diagram respectively. On a plot of K_2O vs. SiO_2, chemical trends between two stages diverge on felsic compositions. K_2O composition of S1 is larger than that of S2 at a given SiO_2 content (S1: K_2O = 1.6 wt.%; S2: K_2O = 1.3 wt.%, at SiO_2= 63.8 wt.%). Cr contents of S1 mafic samples are remarkably higher (Cr = 120 - 180 ppm) than those of S2, characterized by depleted Cr concentration (Cr = 32 - 66 ppm) below 55 wt.% SiO_2contents.
Different trends between the two stages in the FeO*/MgO vs. SiO_2diagram suggests that each eruptive stage was derived from a distinct magma system rather than a single long-lived magma system. Heterogeneous features of host rocks with mafic inclusions in all units indicate that felsic and mafic magmas coexisted and mingled. Mixing processes of different magmas are also supported by disequilibrium phenocryst assemblage, such as olivine and quartz at the same unit. At least four end members can be assumed at FV: S1 mafic/felsic, and S2 mafic/felsic. S1 and S2 felsic end members can be characterized as bearing quartz and hornblende, respectively, on the basis of phenocryst assemblages of host rocks. No changes in the ratios of incompatible elements between S1 and S2 mafic samples, and depletion of Cr contents of S2 mafic samples suggest that more evolved, that is fractionated, mafic magma could be injected and mixed with felsic magma at the later stage (S2).

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Keywords: Futamata volcano, Nasu volcano group, ejecta stratigraphy, magma plumbing system

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Magma of the Haruna-Caldera forming eruption in view of Shirakawa pyroclastic flow deposits-

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Haruna Volcano is a composite volcano which is located in the southern end of the NE Japan arc. Geshi and Takeuchi (2012) divided its whole activity into older activity (-240ka), and newer activity (45ka-). Newer activity began with the Haruna-caldera forming eruption that produced pumice flow (1.0km^3 DRE) and pumice fall (0.2km^3 DRE)(volumes after Yamamoto (2013)). Oishi *et al.* (2011) classified the flow deposits into "Shirakawa" and "Satomi" based on the reflactive indices of plagioclase. The purpose of this study is to clarify the eruption triggering process and magma behavior in the reservoir prior to the caldera eruption in view of Shirakawa pyroclastic flow deposits. We also compared our data with those of Satomi pyroclastic flow deposits (Okano and Suzuki, 2019; JpGU).
Referring to preceding studies (e.g. Oishi *et al.*, 2011), we surveyed 12 outcrops of summit, northern foot and southeastern to southern foot. We could observe the basal part along with upper part only in Koujin outcrop. We sampled juvenile pumice clasts at 8 outcrops. The pumices were classified into white pumice and gray pumice. The gray pumices were typically observed in the basal part of the Koujin outcrop along with white ones. The whole rock SiO_2 contents of pumices varied between 61.9 and 65.4 wt.% (N=44), indicating that they are dacite. The composition does not vary with pumice color and the horizon in the Koujin outcrop. We also note the pumice clasts of Shirakawa pyroclastic flow deposits and Satomi pyroclastic flow deposits (62.8-66.3 wt.% in SiO_2) are not indistinguishable.
Pumice clasts have Pl + Qt + Hb + Opx + Cum + Fe-Ti oxides as phenocrysts, all of which form aggregates. This means that these crystallized in equilibrium. Some phenocrysts have disequilibrium texture such as dissolution of Qt, dusty zone of Pl, aggregates of small Opx (after dehydrogenation decomposition of Hb). Change of melt composition to less-fractionated direction can be the cause for the disequilibrium textures. Decompression can be the additional case for the decomposition of Hb (Rutherford and Hill, 1993). However, we deny the decompression origin, because magmas seem to have ascended very rapidly in conduit judging from absence of groundmass microlites in most pumices. Less-fractionated melt can be generated by either heating by hotter magma or mixing with hotter magma. For the magma mixing, we propose the hotter magma was aphyric since we have not observed phenocrysts derived from the hotter magma. On the other hand, Hb margin on Opx (both ordinary phenocryst, and small-orthopyroxene aggregates) recorded decrease of temperature, although some phenocrysts and aggregates lack in the Hb margin. Appearance of above texture does not vary with pumice color. Above textures are also found in pumices of Satomi pyroclastic flow deposits. Based on above, we propose the magmatic processes in the reservoir just prior to the caldera eruption. First, temperature of felsic magma reservoir rose due to the hotter magma. The change of melt composition due to heating or mixing occurred inhomogeneously (less-influenced zone and more-influenced zone). The crystals in the more-influenced zone came to have reaction rims. In the last, crystals from two zones came to coexist in a pumice due to syneruptive mixing of the two zones. We infer that Hb margin on small-orthopyroxene aggregates formed when magmas of two zones mixed.
We lastly clarify the difference between white and gray pumices. Groundmass microlites are absent in white pumices, whereas microlites are present in gray pumices. We thus judge the difference in color is due to different groundmass crystallinity (Gardner *et al.*,1998). Since gray pumices occur in basal part of

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the deposits, we propose that slow ascending of magma along with conduit formation, that probably occurred before the onset of the caldera-forming eruption, led to formation of gray pumices.

Keywords: Haruna volcano, Pyroclastic flow, Magma mixing, Heating from hotter magma, Eruption trigger

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Magma plumbing system in the caldera-forming eruption of Haruna volcano indicated by Satomi pyroclastic flow deposit

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Haruna volcano is a large stratovolcano, located at the southernmost point of the NE Japan arc. Geshi and Takeuchi (2012) divided its activity into two stages (older and newer period). Haruna volcano had not erupted for 200,000 years after the older period. The activity of the newer period began at 45 ka with Haruna-caldera-forming eruption. This eruption emplaced 1.2 km^3 DRE of pyroclastic fall and flow deposit (Yamamoto, 2013). Oishi *et al.* (2011) showed the pyroclastic flow deposit can be divided into two groups, Satomi and Shirakawa pyroclastic flow deposit, based on the refractive indices of plagioclase phenocrysts.

Structure of magma plumbing systems and the triggering mechanisms of eruptions are basic knowledge to characterize eruptive activities in each volcano. Petrological studies on the ejecta have been used for understanding them. Such studies lead to the forecasting of future eruptions, which is strongly requested by society. Unfortunately, limited petrological studies focusing on detailed petrography have been conducted for Haruna volcano, except the study of the middle sixth century eruption (Suzuki and Nakada, 2007). With this motivation and background, we investigated the Satomi pyroclastic flow deposit of 45 ka Haruna-caldera-forming eruption.

In this study, pumice blocks of Satomi pyroclastic flow were sampled at three sites of the southern foot of Haruna volcano. The samples were classified as white pumice, gray pumice, whitish gray pumice and grayish white pumice. These have whole-rock compositions ranging from 62.8 to 66.3 wt.% in $SiO_{2,}$ showing that these pumices are dacite. There is no great difference among four types of pumice in whole-rock compositions. Compared with the data on pumices of Shirakawa pyroclastic flow (Kitani and Suzuki, 2019; JpGU meeting), there is no great difference too. Four types of pumice show phenocryst assemblages of Pl + Qt + Hb + Cum + Opx + Fe-Ti Ox. This indicates that these minerals crystallized in equilibrium. There is no great petrographical difference among four types of pumice. Dusty plagioclase and resorbed quartz phenocryst suggest that temperature of the melt surrounding the crystals rose. Temperature of the melt rises when (1) the felsic magma mixes with mafic magma or (2) the felsic magma is heated by mafic magma. Now, the pumices don’ t contain any phenocryst which crystallized from mafic magma like olivine, so if the felsic magma mixed with mafic magma, the mafic magma should be aphyric. Meanwhile, texture of orthopyroxene has recorded fluctuations in temperature of the melt.

We analyzed phenocryst mode of white pumices sampled at Matsunozawa with broad whole-rock compositions (3.6 wt.% in SiO_2). They are strongly porphyritic with 52.3-71.7 vol. % phenocryst, indicating that the magma erupted them was mush-like. It turned out that as whole-rock SiO_2 content increases, phenocryst content increases. The phenocryst content increase is accompanied by quartz increase and Fe-Ti oxide decrease. It might mean the difference in mixing ratio with mafic magma if the felsic magma mixed with mafic magma.

Based on the above, we estimated the state of magma plumbing system of Haruna-caldera-forming eruption. Firstly, there is a mush-like felsic magma which contains crystals above-mentioned. Secondly, mafic magma was injected into felsic magma. As a result, felsic magma mixed with mafic magma or was heated by mafic magma. This temperature rising event might have triggered the eruption.

Pumices contain many crystal fragments. It is assumed that high shear stress at the conduit walls promoted crystal fragmentation. Thus, the origin of gray pumices which contain more crystal fragments

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than white pumices might be the magma which had ascended along the conduit margins where the shear stress is highest.

Keywords: Haruna volcano, Caldera-forming eruption, Pyroclastic flow, Mush-like felsic magma, Magma mixing, Heating from hotter magma

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Petrology of the Minamiryu-ga-banba in Hakusan Volcano

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The Minamiryu-ga-banba Lava dated at 30 Ka extends from 100 m below a scoria cone on the southern foot of Gozengamine 4 km downslope to Nakahanba. A scoria raft was found on the Minamiryu-ga-banba Lava 1.5 km from the vent, which has identical whole-rock and mineral compositions to the remnants of a scoria cone on the southern slope of Gozengamine. This indicates that the scoria cone is the source vent of the Minamiryu-ga-banba Lava. We report results of whole-rock and mineral analyses of Minamiryu-ga-banba Lava and the scoria cone at the foot of Gozengamine.

Thirty-six samples of scoria clasts from the cone and raft and Minamiryu-ga-banba Lava were examined under an optical microscope and analyzed by XRF and by EPMA. Lava samples contain phenocrysts of plagioclase, orthopyroxene, hornblende and magnetite set in the groundmass of plagioclase, clinopyroxene, olivine, quartz, ilmenite and glass. Scoria carries phenocrysts of plagioclase and olivine with a small amount of hornblende and orthopyroxene. Plagioclase with or without dusty zone is present. Hornblende phenocrysts are opacitized. The groundmass contains abundant glass and vesicles. Scoria raft contains plagioclase and olivine phenocrysts in the groundmass of abundant glass and vesicles.

Whole-rock SiO_2 of scoriae of the raft and cone largely overlaps, ranging from 55 wt%–60 wt%, while the Minamiryu-ga-banba Lava shows a limited range of 60 wt%–62 wt%. The lava and the scoriae form a single liquid line of descent with decreasing TiO_2, FeO, MnO, MgO, CaO and P_2O_5, increasing Al_2O_3 and K_2O and invariant Na_2O, with increasing SiO_2. These variations could be interpreted by crystallization differentiation of phenocrystic phases except TiO_2 and K_2O, which requires end component with higher TiO_2 and K_2O. The whole-rock compositions of the Nohi Ryolite, basement of the Hakusan Volcano, plot on the extension of lines connecting the scoriae and the Minamiryu-ga-banba Lava. This strongly suggests contamination of the Minamiryu-ga-banba Lava by the Nohi Ryolite.

Plagioclase has An34-61 with a peak An42 in the raft and An36-61 with a peak An42 in the cone. Olivines in the raft and the cone have Fo69-86 with a peak Fo85 and Fo76-86 with a peak Fo84, respectively, and orthopyroxenes in the raft and the cone show Mg#62-84 with a peak Mg#64 and Mg#62-75 with a peak Mg#63, respectively.

Whole-rock and mineral compositions of the scoriae of the raft and the summit cone are essentially identical and were parts of a scoria cone formed by an earlier Strombolian phase, which was subsequently destroyed by extruding Minamiryu-ga-banba Lava.

Although the Minamiryu-ga-banba Lava is dated to 30 Ka by K-Ar method, the lava preserves the original flow morphology as clear as the 2.2 Ka Shiramizunotaki Lava. In addition to this, the summit scoria cone exposes on the surface and is neither covered by soil nor later tephras. Besides this scoria cone, the only known mafic tephra carrying olivine phenocrysts is the Minamiryu Tephra, that has a easterly dispersal axis and widely covers Murodo, Midagahara and Minamiryu-ga-banba. Although the source vent of Minamiryu Tephra is considered to be in the summit region now buried by the Kengamine, our

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observations suggest a correlation of the summit scoria cone and the Minamiryu Tephra. This means that the Hakusan Minamiryu eruption at 2.2 Ka was much larger in magnitude and formed not only the Shiramizunotaki Lava, Kengamine and the Hakusan Minamiryu Tephra, but also the Minamiryu-ga-banba Lava.

Keywords: Hakusan volcano, scoria, scoria raft, lava flow

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Tephrochronological relations of Middle-Pleistocene tephra derived from Myoko Volcanic Group and the pumice and scoria fall deposits found in Kosha Volcano, Central Japan

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Kosha Volcano, locating between Iiyama Basin and Nagano Basin, is a small stratovolcano erupted between 0.3 and 0.2 Ma (Kaneko et al. 1989). There are no geological studies about this volcano after Saito (1955) until Kaneko et al. (1989). Togashi and Akabane (1991) reported two tephra groups within Kosha Volcano. The lower is named Kosha Pumice flow and fall deposits (Kf/Kp), which consists of four pumice layers (A1-A4) with hornblende crystals. The upper consists of four pyroxene-rich scoria layers (A5-A8). They inferred A5- A8 are derived from another volcano locating in the west. They presumed that Kf/Kp originated in Iimori-yama Lava Dome (IM) which is the last product of Kosha Volcano because of presence of hornblende crystals. However, Kf/Kp does not include clinopyroxene crystals, which are common mineral in all of the Kosha products including IM. Hayatsu et al. (1994) and Suzuki (2001) reported several tephra layers distributed around Myoko Volcanic Group. In particular, Ojika Scoria Group (OS) derived from Kurohime volcano and Iz-KT tephra group derived from Iizuna Volcano is possible to correlate to tephra layers at Kosha Volcano.

In order to clarify the origin of these tephra layers, we carried out mineralogical analysis (Takasugi et al. 2018, Fall meeting of the volcanological society of Japan). The results indicated that A5-A8 scoria groups are correlated to OS. Chemical compositions of orthopyroxene and hornblende of A3 and A4 tephra differed from those of Kosha products including IM, suggesting that A3 and A4 are not originated from Kosha volcano. Geological occurrences, mineral assemblages and chemical compositions of orthopyroxene and hornblende crystals of A3 and A4 tephra were very similar to those of KTa tephra, which composes the upper most layer of Iz-KT, suggesting that A3 and A4 tephra are correlated to Iz-KT tephra group. This time, we determined chemical compositions of Iz-KT layers to correlate tephra layers at Kosha Volcano.

Titanomagnetite crystals of three tephra layers of Iz-KT (KTa, KTb, KTc) showed distinct chemical compositions. Particularly, three tephra layers showed different Al contents, suggesting that KTa was correlated to A3 and A4, KTb was correlated to A2, and KTc was correlated to A1. Because A1-A8 tephras are covering the pyroclastic flow deposits and lavas of Kosha Volcano, this result suggests the age of the activities of Kosha Volcano is to be

guessed to be elder than the production of KTc, which considered to be supplied around 160 ka according to Suzuki (2001).

Keywords: Myoko Volcanic Chain, tephrochronology, SEM-EDS, orthopyroxene, titanomagnetite, Quaternary research

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Geologic and petrologic study of the Kamo monogenetic volcanic field,Southern Kyushu,Japan

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Kamo monogenetic volcanic field consists of small-volume basaltic volcanoes forming part of the volcanic front of Southern Kyushu that extend to the Southern Island of Japan. These volcanoes include the late Pleistocene Aojiki volcano formed at about ~100ka and two Holocene maar volcanoes, the Sumiyoshiike(SM:0.5km in diameter) and Yonemaru (YM:1.2km in diameter) that erupted at 8.2ka and 8.1ka respectively (Nagaoka 1988, Nagaoka et al.2001, Moriwaki et al,2016). These two maars were formed through phreatomagmatic eruptions during sea level high stand along the northern edge of the Kagoshima graben, where large caldera forming volcanism has been concentrated, leading to the accumulation of widespread dacitic and rhyolitic tephras (Nagaoka 1988).While the volume of erupted basaltic magma in this area is low, they have played a significant role in the evolution of the felsic magmas in the Kagoshima graben (Kimura et al.2015).

Lithostratigraphic studies for these maars have been reported by Moriwaki et al. (1986) and Moriwaki (1992) in which different lithofacies were identified and described. In this study, we present geologic and petrologic examinations of the products in order to understand the mafic magma process with focus on the maar forming eruptions. In addition, we also provide data for the older Aojiki volcano identified in between the two maars.

From our field investigations, most of the pyroclastic sequence from the two maars were stratified and consists of thin beds of volcanic ash, scoriaceous lapilli and bombs. These tephra deposits are generally rich in accidental clasts, made up of brown pumice and laminated silts sediments, especially at the proximal part of the maar crater. The brown pumice clasts are the product of Ito Ignimbrites coming from the Aira caldera that erupted ~29ka covering a vast area around Southern Kyushu (Aramaki, 1984), while laminated silts sediments formally grouped into the Kamo Formation, considered to be the basement rock of the area (Kobayashi et al.2004, Kagawa and Otsuka,2000).

At YM, the lower outcrop consists of alternating thin beds of ash and lapilli of base surge origin with characteristics cross and planar laminated structures.

The upper outcrops for both maars are richer in juvenile pyroclasts especially at SM. The scoria cone of Aojiki volcano, at attitude of 213m, consists of variable pyroclast sizes ranging from ash to bomb and block. Meanwhile, the Aojiki lava found below the cone is characterized by clinkery aa lava surface textures and massive blocky lava structure.

Petrological features of the juvenile pyroclasts from the two maars are variable with common phenocrysts of plagioclase and clinopyroxene and microphenocryst of olivine set within a glassy groundmass of same minerals exhibiting mostly hyalo-ophitic to intersertal textures. Honey comb texture defined by numerous small melt inclusions in plagioclase phenocrysts are common in the YM products.

Whole rock geochemical data indicates that the juvenile pyroclasts are composed of mostly basalts and

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minor basaltic andesites. All the juvenile pyroclasts can be defined as tholeiitic magma series of mainly medium K characteristic. Distinct chemical trends among the three volcanoes suggest independent magmatic evolution within each volcano. Compositional ranges are narrow for SM (SiO_2 :47.03wt.%-48.01wt.%, MgO: 6.10-6.51 wt.%),Aojiki scoria(SiO_2:50.30 wt.%-50.90 wt.%, MgO: 4.48-4.68 wt.%) and lava(SiO_2:48.06 wt.%-48.81wt.%, MgO: 5.47-5.66wt.%), while a wide compositional range can be recognized in the YM products(from lower to upper). The eruptive products of the upper section (distal products) of the YM are more evolved with SiO_2 content ranging from 51.43 wt.% to 52.10wt.% with low concentration of Ni, Cr, Co compared to the lower and middle products with almost similar concentration of major and trace elements.

Highly Incompatible trace element ratios such as Y versus Zr and Ba versus Y diagrams indicate a distinct correlation line within YM products, which implies fractional crystallization (FC) was not the main magmatic process. While no differences are observed in the SM and Aojiki samples suggesting that these products were formed by FC. REE patterns between the mafic and most evolved samples of YM are remarkably different, while those of SM and Aojiki are almost similar. Mineral chemistry data for core composition of plagioclase phenocrysts for YM is broad showing Anorthite content of 36-90% and 60 -90 % for upper and lower products respectively. These petrologic features of YM products strongly suggests magma mixing process derived from at least two distinct magma sources.

Keywords: monogenetic, maars, Kagoshima graben, basalt, mixing

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Investigation on Lava Tube Caves in Manno lava flow of Mt.Fuji

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[Introduction]
Manno lava flow of Mt.Fuji is a very old lava flow and the eruption is said to be before BC 10000, the silicic acid weight fraction is as low as 49.7% [1)]. Manno lava flow is known to have Manno Fuketsu lava cave (another name is Dainichi Ana lava cave), Yasiki Ana lava cave,Kobou Ana lava cave, Mado Ana lava cave, Ginga Fuketsu lava cave, Kannon Ana lava cave (already buried) [2, 3)]. These are thought to be a series of lava tube cave systems and considered the oldest lava caves in Mt. Fuji. Among them, Mannno Fuketsu lava cave is the longest lava tube cave in Mannno lava flow with a total distance of 908 m in Mannno lava flow [2, 3)]. The yield strength and the surface tension of Manno lava flow were estimated by refering to the Mannno Fuketsu lava cave survey maps [2, 3)] .

[Manano Fuketsu lava tube cave and lava yield strength]
A photograph inside the Manano Fuketsu lava cave (Dainichi Ana lava cave) is shown in Photo 1, and a survey map in the horizontal section and longitudinal section is shown in Fig.1. A cave slope angle $\alpha = 2.5$ ° is obtained from the height difference (30 m) in the longitudinal sectional view and the cave length (700 m). The cave height is approximately 5 m. The lava yield strength f_B is estimated from $f_B = H(\rho g \sin \alpha) / 4$ by the flow limit condition of the Bingham fluid flowing in the inclined circular tube [4)]. When the lava density is 2.5 g / cm ^{3}, $f_B = 1.32 \times 10^4$ dyne / cm ^{2} can be obtained from the above conditions. It is considered to be a reasonable value for basalt lava having a silicic acid weight fraction of 49.7%.

[Lava stalactite and surface tension value]
Many lava stalactite are found in the ceiling of Manno Fuketsu lava cave(Dainichi Ana lava cave). When the lava is drained through the lava tube, the residual molten lava stagnated on the ceiling is hanging down from the ceiling by forming the lava stalactite. The surface tension of lava can be estimated from the pitch of this lava stalactite[5)]. From the stability limit condition of the liquid film adhering to the ceiling, the specific pitch $P = 2\pi (\gamma / g\rho)^{1/2}$ of the wave motion of the liquid film is obtained. Here, γ is the surface tension of the lava, g is the gravitational acceleration, and ρ is the density of the lava. Therefore, we can obtain the surface tension $\gamma = P^2 g\rho / 4\pi^2$ of the lava by measuring the pitch P of the periodic position of the lava stalactite descent from the ceiling [5)]. The pitch measured in the Manno Fuketsu lava cave is roughly P = 3 to 4 cm (see Photo 2), and $\gamma = 560$ to 990 dyne / cm as the surface tension is obtained. The surface tension is considered to be a reasonable value[5)].

[Conclusion]
The yield strength and the surface tension of the Manno lava flow were estimated by the tube shape and internal structure of Manno Fuketsu lava cave(Dainichi Ana lava cave). Both values obtained are considered to be reasonable values for basalt. Yield strength and surface tension are the same as other examples of lava flows of Mt. Fuji [4, 5)]. We are planning to continue to investigate other lava tube cave of Mt. Fuji which has not been studied yet.

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Keywords: Fuji, lava tube, lava flow, lava staractite

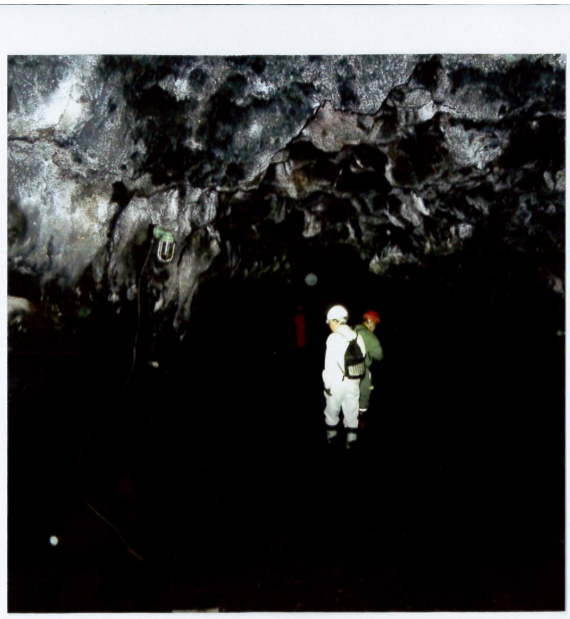

写真１　万野風穴内部

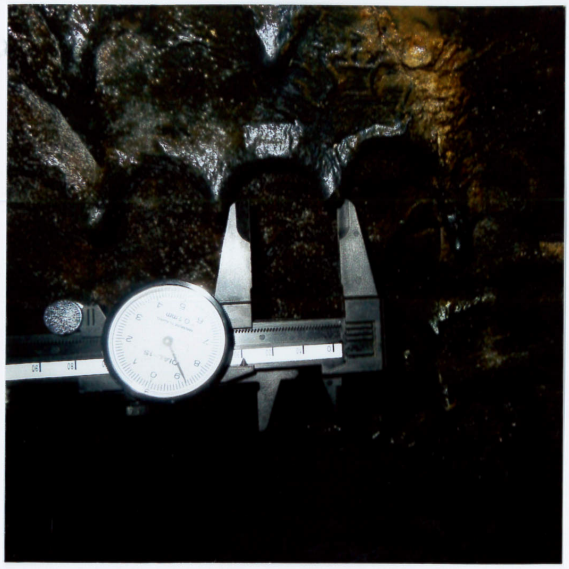

写真２　万野風穴天井の溶岩鍾乳

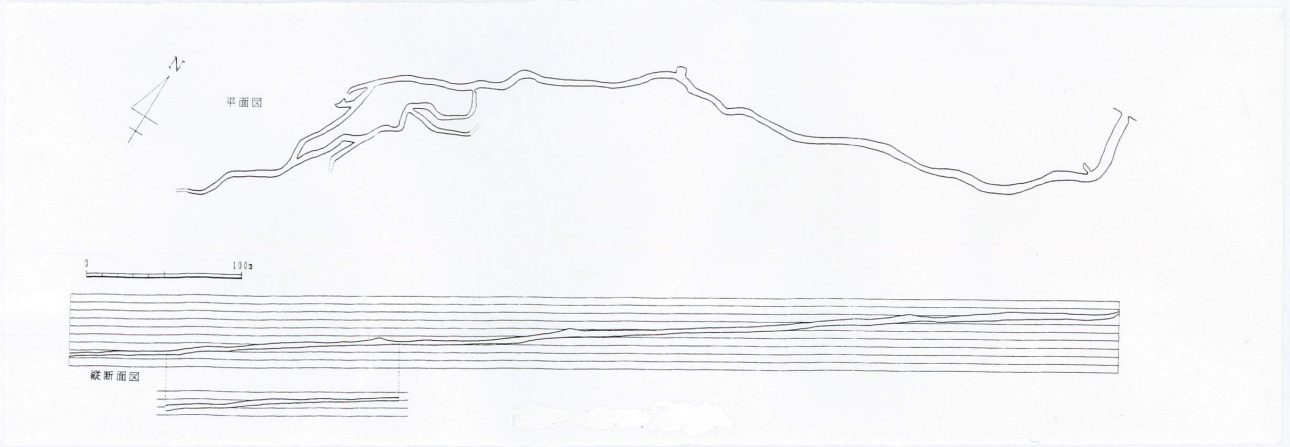

図１　万野風穴の水平及び縦断面図

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[E] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[S-TT42] Recent Advances in Exploration Geophysics 2019

convener:Hitoshi Mikada(Kyoto University), Yoshihisa Iio(Disater Prevention Research Institute, Kyoto University), Nobukazu Seama(Department of Planetology, Graduate School of Science, Kobe University), Junichi Takekawa(Graduate School of Science, Kyoto University), Chairperson:Yusuke Watanabe(Graduate School of Engineering, Kyoto University), Junichi Takekawa(Graduate School of Engineering, Kyoto University)

Geophysical exploration methods are widely used to estimate physical or chemical properties of media that are located in the environment where it is difficult for human beings to access. We would welcome presentations and discussions on theories, applications, case studies in which geophysical exploration schemes are applied for using artificial/natural signals or potentials. A proceeding paper within 4 A4 pages for each submission is to be asked to prepare after the acceptance based on the quality of the abstract of the submission and will be published electronically with doi on EarthDoc (http://earthdoc.eage.org/publication/eventoverview?p=78) under MoU with the European Association of Geoscientists and Engineers.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[STT42-01] Numerical modeling of the effect of borehole stress concentration on sonic logging measurements in shale formations

*Shimin - Zhou[1], Xinding - Fang[1] (1.Southern University of Science and Technology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[STT42-02] Fundamental study on hydraulic fracturing simulation with DEM under high pressure and temperature condition

*Hayate Ohtani[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.kyoto university)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[STT42-03] A fundamental study of proppant behavior in hydraulic fractures using particle based numerical simulations

★Invited Papers

*Junichi Takekawa[1], Hitoshi Mikada[1] (1.Graduate School of Science, Kyoto University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[STT42-04] Monitoring of mass density variation inside active volcanoes with cosmic-ray muography

*Laszlo Olah[1], Hiroyuki K. M. Tanaka[1], Gergo Hamar[2], Dezso Varga[2] (1.Earthquake Research Institute, The University of Tokyo, 2.Wigner Research Centre for Physics of the Hungarian Academy of Sciences)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[STT42-05] New development and operation of the EM-ACROSS: an investigation at Mount Kusatsu-Shirane

★Invited Papers

*Kuo Hsuan Tseng[1], Yasuo Ogawa[1], Takahiro Kunitomo[3], Masato Fukai[1], Hiroshi Ichihara[2] (1.Earth and Planetary science, Tokyo Institute of Technology, 2.Graduate School of Environmental Studies, Nagoya University, 3.Nagoya University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[STT42-06] A feasibility study to identify supercritical geothermal reservoirs on southern Kyushu Island using DTS and DAS systems

★Invited Papers

*Junzo Kasahara[1,5], Yoko Hasada[2,1], Hiroyasu Kuzume[1], Fujise Yoshihiro[4,1], Hitoshi Mikada[3] (1.ENAA, 2.Daiwa Exploration and Consulting Co., 3.Kyoto Univ., 4.WELMA Co. Ltd., 5.Shizuoka Univ.)

Numerical modeling of the effect of borehole stress concentration on sonic logging measurements in shale formations

*Shimin - Zhou[1], Xinding - Fang[1]

1. Southern University of Science and Technology

In oil or gas exploration, sonic logging is a routine approach for formation evaluation. The drilling-induced stress redistribution around the wellbore can cause changes in the elastic properties of the near wellbore formations. This can make the sonic logging measurements deviate from the response of the virgin formations. The influence of borehole stress concentration on sandstones has been investigated by a number of researchers, we extend the study of this problem to anisotropic shale formations. To model the effect of borehole stress concentration on the elastic properties of shales, we need to first calculate the borehole stress distribution and then construct a rock physics modeling workflow to compute the changes in elastic properties under given stress conditions. We assume that shale formation is a transversely isotropic medium and its symmetric axis can be in an arbitrary direction with respect to the borehole axis. In our simulation, we first use the borehole stress solution of Amadei to calculate the stress distribution around the borehole, and then the elastic properties of the formation at each position around the wellbore is modified based on the local stress tensor by using a micro-crack rock physics model. The adopted rock physics model considers the influence of both intrinsic anisotropy and stress-induced anisotropy. This results in an inhomogeneous anisotropic borehole model that can reflect the effect of borehole stress concentration on near wellbore shale formations. Based on the proposed modeling workflow, we create a number of different scenarios that correspond to different shale formations and in-situ stress conditions, and then study the characteristics of the compressional and shear wave velocity variations in these situations.

Keywords: Sonic logging, borehole stress concentration, shale, rock physics modeling, in-situ stress

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Fundamental study on hydraulic fracturing simulation with DEM under high pressure and temperature condition

*Hayate Ohtani[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. kyoto university

One of the most attractive topics in geothermal development is the realization of enhanced geothermal systems (EGS) in ductile zones. Thermal energy extraction from hot dry rock may require hydraulic fracturing through rocks in ductile zones, where rocks are supposed to deform in a ductile way due to the high pressure and high temperature (HPHT) conditions. One of the key factors in its realization is, therefore, to understand their mechanical behaviors of ductile rocks and of hydraulically created fractures under the HPHT condition, which have not been well investigated in the past.

Numerical simulations are widely accepted as one of the effective approaches to understand the mechanism of hydraulic fracturing, and numerical studies taking cooling effects from injected fluid on hydraulic fracturing into consideration have been conducted. Though distinct element methods (DEM) are frequently used to understand brittle failure or ductile deformation mechanism of rock in biaxial or triaxial compression tests, hydraulic fracturing simulations including both ductile behaviors and cooling effects due to injected fluid in the HPHT environment has not been fully investigated yet. Since the mechanical response to the fluid injection shows drastic changes at the brittle-to-ductile transition condition, incorporation of the transition behavior of granite into DEM is an essential step.

In this study, we demonstrated a series of hydraulic fracturing simulations with degradation approaches for the bond properties in DEM, i.e. bi-linear approximation model and degradation model, to replicate semi-brittle or ductile behavior at the HPHT condition including hydro-thermo-mechanical model. The numerical simulation results showed that results from bi-linear approximation model, which is suitable for replicating ductile behavior of granite, were consistent with laboratory experiment results under the HPHT condition. We can observe the cooling effect of rock mass due to injected fluid, while a considerable interaction between solid and fluid cannot be observed due to the shortness of injection time.

Keywords: Hydraulic fracturing simulation, Distinct Element Method, Ductility, Hydro-Thermo-Mechanical model, High Pressure and High Temperature, Geothermal Energy Development

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A fundamental study of proppant behavior in hydraulic fractures using particle based numerical simulations

*Junichi Takekawa[1], Hitoshi Mikada[1]

1. Graduate School of Science, Kyoto University

Hydraulic fracturing technique has been widely used in the development of unconventional oil reservoirs and geothermal reservoirs. To prevent the induced fractures from closing, supporting materials (proppant) are pumped into the induced hydraulic fractures. The ultimate goal of hydraulic fracturing is to keep high conductive flow paths from the formation to the wellbore. Recently, a new technique has been proposed to improve the fracture conductivity by making open channels throughout the proppant pack. In this technique, fluid with and without proppant is alternately pumped into the well. This treatment creates discontinuous proppant pillars in a hydraulic fracture, and then, the fracture conductivity could be improved significantly. However, proppant slurry behavior inside the fracture still remains poorly understood.
In the present study, we applied a smoothed particle hydrodynamics (SPH) method to the fluid-solid interaction analysis in order to investigate proppant behavior inside the fracture. Our final goal is to establish analysis method for slurry behavior in hydraulic fractures. As a preliminary step toward the final goal, we simulate the Couette flow between coaxial cylinders to investigate the accuracy of the coupled simulation with the SPH method. We evaluate the L2-norm error as a function of the number of particles along the diameter of the inner cylinder. As a result, about 15 and 20 particles are required to achieve less than 15 % and 10 % error, respectively. Based on this result, at least 20 particles along the diameter of proppant grains should be used. In the future study, many effects (viscosity of fluid, grain shape, fracture roughness) on the efficiency of creating open channels will be investigated by using the proposed method.

Keywords: proppant, numerical simulation, particle method

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Monitoring of mass density variation inside active volcanoes with cosmic-ray muography

*Laszlo Olah[1], Hiroyuki K. M. Tanaka[1], Gergo Hamar[2], Dezso Varga[2]

1. Earthquake Research Institute, The University of Tokyo, 2. Wigner Research Centre for Physics of the Hungarian Academy of Sciences

Muography is an innovative imaging technique for investigation of large-sized natural and human-made objects based on the measurement of absorption rate of cosmic-ray muons [1]. The monitoring of mass density variation occured during volcano eruptions is a possible applicability of muography. The first large-sized, high-resolution muography observatory is under development based on Multi-Wire Proportional Chamber technology (MMOS) for monitoring of mass density variations in the vicinity of Minamidake crater of Mt. Sakurajima [2,3]. An automated analysis framework provides real-time data and allows analysis and visualization of the variations of muon flux and average mass density across the crater regions via a web-server [4]. The MMOS system consists of five tracking systems with the total surface of 4 square meters is operated at a distance of 3 kilometers from Showa crater in South-West direction since October 2018. The track rates are found stable within 3 % from the backward-direction, which demonstrates that the MMOS system is applicable to detect the average density variation well below the practical limit of about 5 %. We observed a decrease in average density across the West side of Minamidake crater during the ongoing data taking period, which suggests that the amount of material has decreased due to the consecutive occurred eruptions between 30th November 2018 and 11th of January 2019. The extension of MMOS system is scheduled up to the sensitive surface of 20 square meters between 2017-2021. The density-length variation of 5 (10) % is expected to be detected within 5-20 (2-8) days with 68 % confidence level with the designed muography observations system.

[1] H. K. M. Tanaka, L. Olah, Overview of Muographers, Phil. Trans. R. Soc. A 377, 20180143 (2019) https://doi.org/10.1098/rsta.2018.0143
[2] L. Olah, H. K. M. Tanaka, T. Ohminato, D. Varga, High-definition and low-noise muography of the Sakurajima volcano with gaseous tracking detectors, Scientific Report, 8:3207 (2018) https://doi.org/10.1038/s41598-018-21423-9
[3] L. Olah, H. K. M. Tanaka, G. Hamar, D. Varga, Investigation of the limits of high-definition muography for observation of Mt Sakurajima, Phil. Trans. R. Soc. A 377, 20180135 (2019) https://doi.org/10.1098/rsta.2018.0135
[4] L. Olah, H. K. M. Tanaka, G. Hamar, D. Varga, Muographic observation of density variations in the vicinity of Minami-dake crater of Sakurajima volcano, Journal of Disaster Research (submitted research article)

Keywords: Muography, Volcanology, cosmic-ray muon, density monitoring, gaseous detector

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New development and operation of the EM-ACROSS: an investigation at Mount Kusatsu-Shirane

*Kuo Hsuan Tseng[1], Yasuo Ogawa[1], Takahiro Kunitomo[3], Masato Fukai[1], Hiroshi Ichihara[2]

1. Earth and Planetary science, Tokyo Institute of Technology, 2. Graduate School of Environmental Studies, Nagoya University, 3. Nagoya University

The Electromagnetic Accurately Controlled, Routinely Operated Signal System (EM-ACROSS) is a specially designed system for controlled source electromagnetic investigation. The EM-ACROSS combines with a stable transmitter system and at least one receiver for obtaining the electric and magnetic field at the observation site. The core purpose of this system is a specifically designed signal which is repeatedly transmitted with high accuracy and precision to against the noise.

An initial experiment was made at Volcano Kusatsu-Shirane in 2017. We designed a superimposed signal with 10 geometric sequences frequencies, same amplitude and randomly chosen phase shift. A function generator, which was synchronized with a GPS clock, stored our designed waveform and sent the signal to an amplifier. There were two sets of grounded dipoles, north-south and east-west. After that signal was enlarged 80 times, the current was injected to the earth by one set of the grounded dipoles for at least 12 hours before switching. The amplifier was monitored and recorded by a digital data logger for obtaining the transmitter data. At the observation area, nine receivers measured the changing of electric and magnetic field. The data was processed by a simply stacking method in frequency domain. This initial experiment presented a good anti-noise ability at higher frequencies (between 1~5 Hz) and indicated a necessity of longer investigation for lower frequency band.

In 2018, we made a new development and operation of this system based on the result of initial experiment. The transmitter system had one more amplifier to inject both the grounded dipole sets at the same time. The chosen frequencies of superimposed signal were selected from the prime number as two sets of quasi-geometric series. The amplitude of lower frequency band was increased to against the noise floor. The system was operated three months for obtaining a better anti-noise ability in low frequency band. A new procedure of data processing was applied to eliminate the non-stationary and non-Gaussian noise. We used weighted stacking method to calculate the final electric and magnetic field.

Compare with the initial experiment, this investigation presents an obvious enhancement in lower frequencies. The large effect of non-Gaussian noise is reduced. A smaller error of the initialized electric field is acceptable for the modeling work.

Keywords: geophysical prospecting, geophysical techniques, controlled-source electromagnetics, signal design

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A feasibility study to identify supercritical geothermal reservoirs on southern Kyushu Island using DTS and DAS systems

*Junzo Kasahara[1,5], Yoko Hasada[2,1], Hiroyasu Kuzume[1], Fujise Yoshihiro[4,1], Hitoshi Mikada[3]

1. ENAA, 2. Daiwa Exploration and Consulting Co., 3. Kyoto Univ., 4. WELMA Co. Ltd., 5. Shizuoka Univ.

Introduction: Supercritical water is drawing the attention of members of the global geothermal community as an important future renewable energy source for the world (*e.g.*, Dobson *et al.*, 2017). NEDO is promoting supercritical geothermal exploration as an important future energy source. There have been several efforts to use the fiber-optic distributed acoustic sensor (DAS). The DAS method is sensing strain or strain rate caused by seismic waves and the spatial resolution is a few meters. Because the temperature at the supercritical point is higher than 374 ˚C, ordinary geophones cannot be used in such supercritical conditions. In contrast, the optical fiber can be used at ~500 ˚C. We evaluated the usefulness of DAS technology on land and concluded that it is comparable to using geophones (Kasahara *et al.*, 2018a). In order to study supercritical water reservoirs, we carried out a simulation using full-waveform inversion (Kasahara *et al.*, 2018b). It was found that physical properties such as Vp, Vs, and density in the reservoir were well retrieved.

Field study: To evaluate the feasibility of our approach in a real geothermal field, we carried out a field study in the Medipolis geothermal field in Kyushu, Japan in fall, 2018. The fiber-optic cable was deployed down to a 977 m depth in the IK-4 borehole. We conducted the distributed temperature sensor (DTS) and DAS seismic measurements in the borehole using the same fiber-optic cable. We also installed 20 sets of three-component geophones along the 2 km long EW line at approximately 100 m spacing.

Results: The maximum temperature was measured as 264 ˚C at 914 m. The DAS data were obtained continuously at every 1 m for 4.5 days. Using the DAS system, we observed seven natural earthquakes between M0.8 and M5.2. The P-wave first arrival of the M5.2 earthquake was observed at the whole depth of 977 m to 0 m. Although the temperature at the 914 m depth was 264 ˚C, any evident seismic attenuation was not observed. In some earthquake records, some surface geophones show large amplitudes on horizontal components at 0.8 seconds after the P first arrivals in the vertical component. To estimate the vertical Vp profile of the surrounding area, we conducted a semblance analysis and obtained the Vp for every 100 m depth interval along the borehole. The Vp is estimated to be approximately 4 km/s and 3.3 km/s between 800–977 m, and between 500–800 m, respectively.

Discussion and conclusions: Although the temperature at a 914 m depth was as high as 264 ˚C, no significant attenuation of P arrivals was observed. The Vp profile in the borehole shows approximately 4 km/s between 800 m and 977 m. It seems no effects by the high-temperature zone. The reason for these measurements might be explained by the wavelengths of natural earthquakes being longer than the thickness of the high-temperature zone.

We observed seven natural earthquakes, but we did not see reflected phases from the deep reflectors. Surface geophones suggest the presence of P-to-S converted waves, and the conversion could be happening just below the study field. Although further studies are needed, the DAS system could supply a very dense vertical seismic array, and with the DAS seismic system and full-waveform inversion method, we could image the deep-seated supercritical geothermal reservoirs if they exist.

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Acknowledgements: This study is supported by the New Energy and Industrial Technology Development Organization (NEDO). Medipolis Energy Co. kindly allowed the use of their IK-4 geothermal well for this study. Mr. Kimura provided us with the Schlumberger hDVS measurements. WELMA Co. provided us with the borehole fiber-optic system and measurement of temperatures in the borehole. The staff of West Japan Engineering Consultants, Inc., helped us during the field study.

Keywords: DAS, Geothermal field, Geothermal reservoir, Seismic monotoring, DTS, Passive seismic source

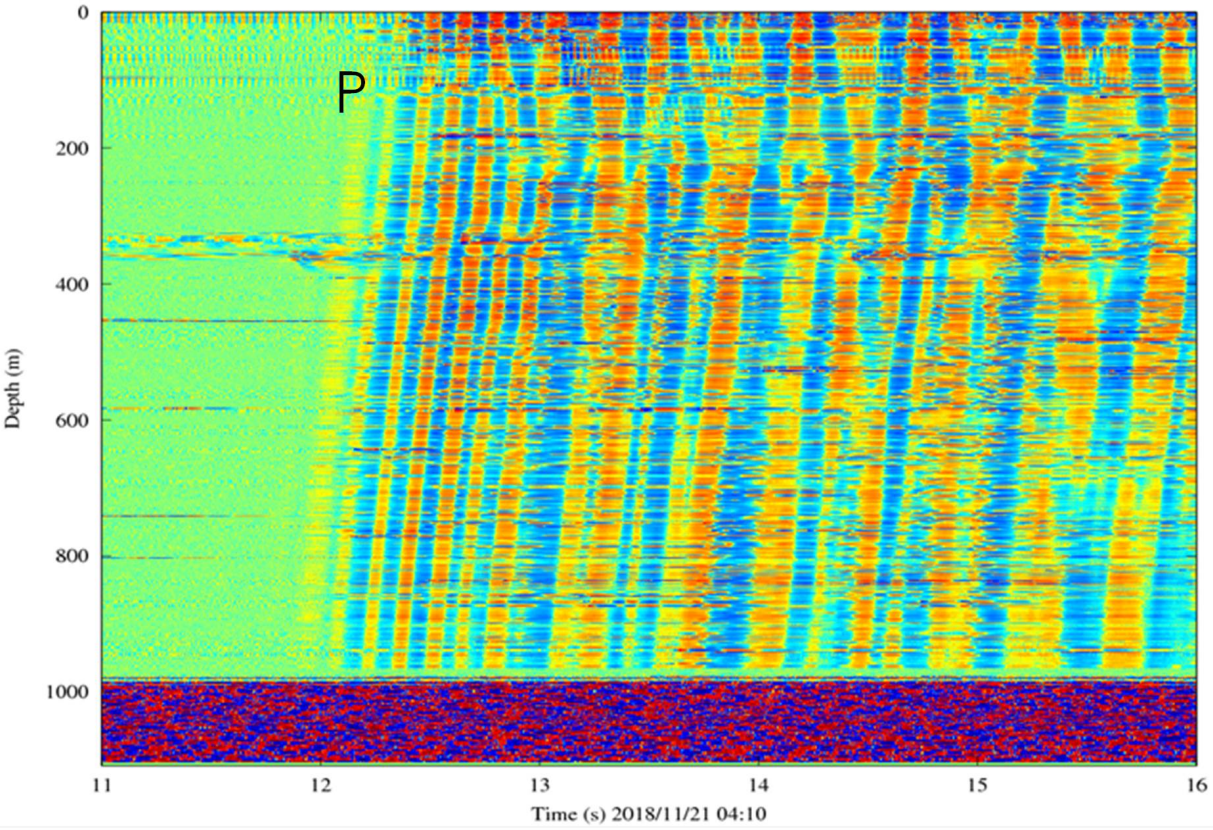

Figure : An M5.2 natural earthquake occurring 100 km focal distance and 123km focal depth recorded by the DAS. The vertical axis is depth from 0 m (top) to 977 m (bottom). The horizonal axis is the arrival time in seconds.

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[E] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[S-TT42] Recent Advances in Exploration Geophysics 2019

convener:Hitoshi Mikada(Kyoto University), Yoshihisa Iio(Disater Prevention Research Institute, Kyoto University), Nobukazu Seama(Department of Planetology, Graduate School of Science, Kobe University), Junichi Takekawa(Graduate School of Science, Kyoto University), Chairperson:Junichi Takekawa(Graduate School of Engineering, Kyoto University), Yusuke Watanabe(Graduate School of Engineering, Kyoto University)

Geophysical exploration methods are widely used to estimate physical or chemical properties of media that are located in the environment where it is difficult for human beings to access. We would welcome presentations and discussions on theories, applications, case studies in which geophysical exploration schemes are applied for using artificial/natural signals or potentials. A proceeding paper within 4 A4 pages for each submission is to be asked to prepare after the acceptance based on the quality of the abstract of the submission and will be published electronically with doi on EarthDoc (http://earthdoc.eage.org/publication/eventoverview?p=78) under MoU with the European Association of Geoscientists and Engineers.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[STT42-07] The observation of active source and ambient noise signals with telecommunication fiber-optic cable in urban area

*Baoshan Wang[1], Xiangfang Zeng[2], Xiaobin Li[3], Weiwei Xu[4], Shanhui Xu[4], Zhenghong Song[1] (1.School of Earth and Space Sciences, University of Science and Technology of China, 2.State Key Laboratory of Geodesy and Earth's Dynamics, Institute of Geodesy and Geophysics, Chinese Academy of Sciences, 3.Earthquake Agency of Yunnan Province, 4.Institute of Geophysics, China Earthquake Administration)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[STT42-08] Comparison of RTM results of time-lapse imaging in foam-assisted EOR

*Rei Tamura[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[STT42-09] The estimation of physical properties of buried targets using the Cole-Cole equation in fictitious wave domain method

*Kohshi Kimura[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[STT42-10] Numerical investigation of permeability anisotropy in porous media using a particle method

*Ryo Masumura[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[STT42-11] **Numerical Description of Flow Channel in Pipe Conduits Considering Solid-fluid Phase Shift with Lattice Boltzmann Method**

*Masaki Iwata[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[STT42-12] Evaluation of anisotropic parameters using virtual cross-dipole data with full waveform approach

*YUSUKE WATANABE[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto Univesity)

The observation of active source and ambient noise signals with telecommunication fiber-optic cable in urban area

*Baoshan Wang[1], Xiangfang Zeng[2], Xiaobin Li[3], Weiwei Xu[4], Shanhui Xu[4], Zhenghong Song[1]

1. School of Earth and Space Sciences, University of Science and Technology of China, 2. State Key Laboratory of Geodesy and Earth's Dynamics, Institute of Geodesy and Geophysics, Chinese Academy of Sciences, 3. Earthquake Agency of Yunnan Province, 4. Institute of Geophysics, China Earthquake Administration

The Distributed Acoustic Sensing (DAS) is a rapidly developing technique, which can provide dense (~ meters) seismic observations. Recently, several experiments were performed using specifically deployed fiber-optic cables, while the seismic observation with telecommunication fiber-optic cable in urban area is still challenging. A 5.2 km long telecommunication fiber-optic cable buried at about 30-cm depth in urban area is used to record active source shots and more than 10-hours continuous ambient noise. We are able to extract seismic signals with the telecommunication fiber-optic cable 9 km from the active source (~Ml0.7). The high-frequency (~ 10 Hz) Rayleigh wave signal emerges from the noise cross-correlation functions. The dispersion information of Rayleigh wave is inverted for Vs at the top 30 m and construct a 2D profile, which helps to assess ground shaking in this area.

Keywords: Urban Area, Telecommunication Fiber-optic Cable, Seismic Monitoring

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Comparison of RTM results of time-lapse imaging in foam-assisted EOR

*Rei Tamura[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. Kyoto University

Due to the demand of oil remains high in the world, enhanced oil recovery (EOR) plays an important role to optimize the oil production from existing reservoirs. Among the EOR methods, foam-assisted EOR, one of the chemical methods, has drawn attention for its enhancement in sweep efficiency and incremental oil recovery. Although the mechanisms of the foam-assisted EOR have been revealed both in macroscopic and in microscopic ways, methods for monitoring the movement of pore fluids in the reservoir have not been fully established yet. Since seismic waves bring the state variation of the pore fluids where seismic wave propagated, we hypothesized that seismic methods could capture the movement of pore fluids in the reservoir in the practice of the foam-assisted EOR. For testing this hypothesis, we conducted numerical experiments on the time-lapse monitoring of foam-assisted EOR using seismic methods. In the previous studies, our numerical results indicated that we could capture the position of foam and the advancement of injected fluids, i.e. foam, CO2, and water, using simple AVO (Amplitude Versus Offset) analysis, and we would like to locate the advancement of the injected fluids in the subsurface through the application of the reverse time migration (RTM) to time-lapse seismic exploration data. Although our results showed the effectiveness of the seismic exploration method, the effect of the recorded component (vertical and horizontal) on the imaging results has not been revealed yet. In our previous study, we only utilized the vertical component for RTM imaging, i.e. information comes from P-wave reflections were mainly used. It is known that wavelength of S wave is shorter than that of P wave, and therefore the improvement of resolution is expected by including S wave in seismic analysis. As horizontal component of recorded data is mainly derived from S waves, we compare the RTM results of horizontal component and vertical component of recorded data. Results of our numerical experiments show that RTM results using horizontal component show the position of advancement of the injected fluids more accurately than those of vertical component. The signals which cannot be seen in the results of vertical components are observed slightly. In this study, we confirm the difference of RTM visualization caused by the components of recorded data used in RTM, and indicate that integration of analyses of RTM results obtained from two components would help the interpretation of results.

Keywords: foam-assisted EOR, Reverse Time Migration, time lapse, numerical simulation

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The estimation of physical properties of buried targets using the Cole-Cole equation in fictitious wave domain method

*Kohshi Kimura[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. Kyoto University

Electromagnetic waves have been used for nondestructive measurements to investigate subsurface anomalies using its reflection. For example, we use Ground Penetrating Rader (GPR) survey to visualize shallow subsurface. Since the travel time of reflection signals tells us the position and the depth of objects in the subsurface, GPR survey has been widely used in many engineering fields.

On the other hand, it is still difficult for the conventional GPR survey to estimate physical properties of the subsurface targets, although there is great demand for estimating physical properties of buried targets has been increasing in recent years.

In our previous study, the possibility of estimating the physical properties of subsurface targets using the Cole-Cole equation has been shown when calculating the complex relative permittivity of the target media for the changes both in amplitude and in phase of the reflected EM waves. However, since the behavior of imaginary part of the complex relative permittivity against frequency usually shows its peak at the range of several GHz, the frequency band used for our proposed method would be limited.
Since the high frequency band, i.e. several GHz, is appropriate for the estimation of physical properties in the fictitious wave domain, we would like to see if the method is applicable to geoexploration of subsurface targets using the Cole-Cole equation. We discuss the validity of our previous conclusions based on the numerical results and try to propose survey methodologies to use the Cole-Cole equation.

Keywords: Cole-Cole equation, Fictitious wave domain method, Ground Penetrating Rader

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Numerical investigation of permeability anisotropy in porous media using a particle method

*Ryo Masumura[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. Kyoto University

It is important to analyze fluid flow in reservoir rocks in the production of oil, gas, and any other fluidal unconventional resources. For reservoir analyses, we require information on hydraulic conductivity of reservoir rocks, which could theoretically be estimated using the Kozeny-Carman equation under the assumption of laminar flow in isotropic media. However, some numerical and laboratory experiments indicated that the subsurface materials show anisotropic feature in permeability. This indicates that it is important to consider anisotropy in reservoir analyses for accurate simulations. In the present study, we simulate fluid flow in three-dimensional models which imitate reservoir rocks by using a smoothed particle hydrodynamics (SPH) method and investigate the effect of porosity, viscosity on anisotropy of permeability.

We assumed four digital specimens which imitate porous media, through which fluid flows depending on pressure gradient in different directions. We measure average fluid velocity component in the direction parallel to the pressure gradient for calculating permeability. The results indicate that our digital specimens show permeability anisotropy in various degrees although the porosity of the specimen is kept constant.

Next, we compare our numerical results with theoretical formulas. Our calculated permeability has good agreement with those derived from theoretical equations when the porosity is high. On the other hand, in the case of low porosity, our results show large difference with the theoretical ones. Since dominant flow path is limited in low porosity specimen, the bulk permeability is directly affected by the anisotropic feature of the dominant flow path. Therefore, permeability of low porosity specimen is sensitive to the direction of fluid flow. Our results indicate that it is important to consider permeability anisotropy in reservoir analyses in view of the porosity of reservoir rocks.

Keywords: permeability, anisotropy, numerical simulation, particle method

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Numerical Description of Flow Channel in Pipe Conduits Considering Solid-fluid Phase Shift with Lattice Boltzmann Method

*Masaki Iwata[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. Kyoto University

It is an essential task to secure the stable flow in metallic pipes for efficient energy production of fluid resources such as oil, gas and geothermal brine. One of the main obstacles to the efficient extraction of fluid is silica scaling which causes pipe clogging due to the precipitation of inorganic salts dissolved in geothermal fluid. Mineral deposition is observed not only in geothermal power plants but also in heat transfer systems of nuclear power plants. Moreover, the precipitation of asphaltenes and the hydrate formation in petroleum or gas pipelines, which are problems similar to silica scaling, deteriorate fluid motion through . As countermeasures against the scaling, pH adjustment for suppressing high molecular polymerization of dissolved silicates has been conducted, but it’ s still in a stage of trial and error. Although lots of experimental researches on scaling prediction have been done based on kinematical analysis on the chemical reaction in the process of silica deposition, the case where the polymerization rate of silicates is independent of temperature has also been confirmed and the limit of chemical approach has been pointed out.

Besides silica scaling, pipe thinning can be cited as a serious issue threatening the stable operation of energy production. This relates a phenomenon in which the piping loses its original function of fluid transport due to the alternation, wear or rupture as a result of interaction between metallic pipe and surrounding environment. Most of the past experimental works on pipe corrosion have focused on pH as a dominant factor of chemical reaction in the wall vicinity. However, it has been said to be difficult to accurately reproduce the actual reduction of pipe thickness in the case of complicated conduits such as elbow piping or downstream of orifice plates since hydrodynamic influence induced by the complicated flow field becomes dominant over the chemical melting effect.

In this research, we combine microscopic and macroscopic analyses which reflect the physical influence over a wide area on silica scaling and pipe thinning. As the simulation method of flow calculation and reactive boundaries between solid and fluid, we use the lattice Boltzmann method (LBM), which has advantages in parallel computation and arbitrary boundary settings. In the process of sequential calculation in the solid-fluid boundaries with LBM, an analogical algorithm of random selection and volume fractions for crystal growth is utilized. Both results of scale visualization and corrosion simulation showed good agreement with real data with high numerical stability. Our research suggested that applications of LBM is effective with regards to various flow analyses in pipe conduits with complex phase shift.

Keywords: LBM, Hydrodynamics, Scale, Corrosion

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Evaluation of anisotropic parameters using virtual cross-dipole data with full waveform approach

*YUSUKE WATANABE[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. Kyoto Univesity

Crack density and orientation in the subsurface dominates velocity anisotropy of S-wave. S-wave anisotropy estimation is also practically useful for the exploration and development of natural resources and understanding tectonics. The estimation of S-wave anisotropy is, therefore, a quite important clue to grasp subsurface stress field information from past to present. In spite of the importance of S-wave anisotropic parameter estimation, S-wave survey in the offshore is quite difficult because S-wave never propagates in the sea water. In our previous study, we proposed a novel analysis scheme in order to estimate S-wave anisotropic parameters with virtual cross-dipole data utilizing seismic interferometry from air-gun sources and a single tricomponent ocean bottom seismometer. However, there are still some limitations to apply our method because of some assumptions for anisotropic medium. In this study, we developed another novel analysis scheme, which combines our virtual cross-dipole method and a full-waveform inversion method. In the proposed method, we set 5 components of the stiffness matrix, anisotropic azimuthal angle and dip angle as estimated parameters. This strategy makes the inversion process stable. For a performance test of this scheme, we conducted simple numerical experiments with a numerical model containing an anisotropic target. The numerical results indicate that the proposed method could provide anisotropic information in the subsurface with sufficient accuracy.

Keywords: Seismic Interferometry, Cross-dipole survey, S-wave survey, S-wave anisotropy, Full waveform inversion

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[E] Poster | S (Solid Earth Sciences)：S-TT Technology & Techniques

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_19

[S-TT42] Recent Advances in Exploration Geophysics 2019

convener:Hitoshi Mikada(Kyoto University), Yoshihisa Iio(Disater Prevention Research Institute, Kyoto University), Nobukazu Seama(Department of Planetology, Graduate School of Science, Kobe University), Junichi Takekawa(Graduate School of Science, Kyoto University)

Geophysical exploration methods are widely used to estimate physical or chemical properties of media that are located in the environment where it is difficult for human beings to access. We would welcome presentations and discussions on theories, applications, case studies in which geophysical exploration schemes are applied for using artificial/natural signals or potentials. A proceeding paper within 4 A4 pages for each submission is to be asked to prepare after the acceptance based on the quality of the abstract of the submission and will be published electronically with doi on EarthDoc (http://earthdoc.eage.org/publication/eventoverview?p=78) under MoU with the European Association of Geoscientists and Engineers.

[STT42-P01] DISCRIMINATION OF HYDRATE BEARING MARINE SEDIMENTS BY USING FREQUENCY BASED ATTENUATION

*Nisar Ahmed[1], Mubasher Ahmad[1], Perveiz Khalid[1] (1.Institute of Geology, University of the Punjab, Lahore 54590, Pakistan)

[STT42-P02] Evaluation of methane hydrate based on attenuation parameter in seismic exploration

*Mizuki Kawabe[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto Unibercity)

[STT42-P03] Estimating the earthquake source mechanism using full waveform inversion

*Jang Iktae[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

[STT42-P04] A quantitative analysis of the passive seismic emission tomography using the lattice Boltzmann method

*Sakemi Yuichi[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

[STT42-P05] A feasibility study for supercritical geothermal energy in enhanced geothermal system

*Tatsuki Ueda[1], Hitoshi Mikada[1], Junichi Takekawa[1] (1.Kyoto University)

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*Nisar Ahmed[1], Mubasher Ahmad[1], Perveiz Khalid[1]

1. Institute of Geology, University of the Punjab, Lahore 54590, Pakistan

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has been used for the current study which calculates a relaxation mechanism, because of pressure equilibrium, attenuation-dispersion of seismic waves occurred. Gas hydrates-bearing marine sediments of the Makran offshore, Pakistan are considered as numerical example for this study. The numerical results show that the seismic wave attenuation and velocity dispersion can be used as a good indicator to identify gas hydrates and both attenuation-dispersion increases with the increase of saturation of gas hydrates. The
maximum P wave attenuation is observed at 64 % gas hydrate saturation. However, in the case of free gas in the
marine sediments, low gas saturation level causes of high attenuation and velocity dispersion.

Keywords: Seismic attenuation, Velocity dispersion, Marine sediments, Gas hydrates, White model, Elastic wave theory

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*Mizuki Kawabe[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. Kyoto Unibercity

In recent years, methane hydrate (MH) has drawn attention as a new domestic energy resource in Japan. Although field production experiments have been conducted in real fields, some MH samples collected in real fields revealed the difficulty to evaluate the amount of MH based quantitative only with the evaluation of bottom simulating reflector (BSR). For efficient development of MH reservoirs, it is therefore important to estimate the thickness of MH concentrated zones accurately. Since MH layer has high attenuation that takes place as a function of propagation path through the attenuating medium, the evaluation of MH using seismic exploration could be an effective approach. However, the previous studies indicated that it is difficult to estimate attenuation structure even if the full-waveform information is utilized. On the other hand, the amplitude of seismic waves passing through MH layer must be affected by its high attenuation, but the approach of full waveform inversion (FWI) has been reported ineffective due to its back-propagation process. In the present study, we hypothesize that additional constraint enables us to estimate attenuation parameter of MH layer without any back propagation of residual wavefield. We assume that the layer structure in the subsurface is known, and the physical properties of MH layer are unknown. Based on the above assumption, we conducted numerical experiments to investigate the effectiveness of inversion based on utilization of full-waveform to provide information on estimation of the amount of MH resources based on the linearized general inverse theory.
In our numerical model, the seismic source and receivers are put in the sea water and on the sea bed, respectively. Synthetic waveforms are created by solving the visco-elastic equation using the finite-difference method. Our numerical experiments revealed that simultaneous inversion of the Lame’ s parameter and attenuation parameter of P-wave (Qp) is difficult. To overcome this, we proposed a kind of the relaxation method, i.e. we separately solve the Lame’ s parameters (and) and Qp in our inversion process. The proposed method can obtain the true value not only the Lame’ s parameters but also Qp with sufficient accuracy. Our numerical results indicate that the seismic exploration can provide valuable information on MH layer by estimating physical properties including the attenuation parameter.

Keywords: methane hydrate, seismic exploration, numerical experiment, finite-difference method

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Estimating the earthquake source mechanism using full waveform inversion

*Jang Iktae[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. Kyoto University

An immediate understanding of the source mechanism of an earthquake after the occurrence is an important task for disaster mitigation to realize a safe society. One of the most important tasks for considering the mechanism of an earthquake is estimating the earthquake source mechanism. Due to the lack of seismic data and computational requirements, the centroid-moment tensor (CMT) solution has been widely used to estimate the focal mechanism until recent years. However, long term observation of the spatial distribution of aftershocks is required to identify the nodal plane that caused the fault motion. Since the earthquake waveform caused by a nodal plane becomes different from that caused by the other conjugate nodal plane, the analysis of full-waveform could be utilized to identify which nodal plane has caused the fault motion so that the focal mechanism of the earthquake could be estimated before the observation of aftershocks. Although some numerical experiments revealed that the possibility of FWI to inversion of earthquake source mechanism, the sensitivity of each fault parameter to full-waveforms has not been fully investigated yet.

In this study, we investigate the applicability of full-waveform inversion (FWI) to determine focal mechanism using numerical experiments. In FWI, L2-norm error function is often used as an objective function to be minimized. We evaluate the effect of some fault parameters (strike, dip, and rake) on the difference of recorded waveforms.

We make a three-dimensional numerical model with an earthquake source, and simulate elastic wave propagation using the finite-difference method. The seismic waves are recorded by receivers located on the ground surface. Subsequently, we slightly change the fault parameters, and then, simulate elastic wave propagation. We calculate the residuals between two recorded waveforms. This procedure enables us to investigate the sensitivity of the parameters on the L2-norm error function. Our numerical results indicate that rake has poor sensitivity whereas the change of strike and dip has a large effect on the recorded waveforms.

Keywords: Full-Waveform Inversion (FWI), Earthquake Source Mechanism, Numerical Experiment

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A quantitative analysis of the passive seismic emission tomography using the lattice Boltzmann method

*Sakemi Yuichi[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. Kyoto University

In recent years, monitoring seismic emission caused by subsurface fluid motion has been widely used in development of hydrocarbon reservoirs. Although this technique can provide the position and the depth of fluid flow in the reservoir, it is difficult to obtain further kinematic information such as flow velocity, fluid viscosity, or pore shape. Previous studies suggested that utilizing waveform analysis of seismic emission would make it possible to image the location of fluid flow, but the mechanism of such seismic emission has not been well revealed. Recently we proposed a model of seismic emission due to fluid flow but found our method has a problem that needs to be worked out, i.e. the utilization of inappropriate sound velocity to reduce the cost of calculation in Lattice Boltzmann method (LBM). In LBM, the incorrect fluid properties are often used since the correct properties induce a numerical instability. This means that it is difficult to evaluate our results in a quantitative manner. In the present study, we focused on this problem and set two types of models to tackle the problem of sound velocity in fluid; one is normal LBM model and the other one has the real sound velocity. We conducted numerical experiments using these models. We have found that the result calculated by the normal model can be modified to fit the results with the real properties by using an appropriate correction coefficient. Therefore, we have concluded that the normal LBM calculation could be adopted to reduce the cost of numerical simulation, and therefore, it is possible to quantitatively evaluate their experimental reuslts.

Keywords: Passive seismic, Fluid flow, Lattice Boltzmann method

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A feasibility study for supercritical geothermal energy in enhanced geothermal system

*Tatsuki Ueda[1], Hitoshi Mikada[1], Junichi Takekawa[1]

1. Kyoto University

Japan has many volcanoes and large potential of geothermal energies. However, since 1996, the construction of large-scale geothermal plants in Japan has been stopped, and the amount of electricity generated by the geothermal plants decreased by about 30 percent compared to the peak time in 1997. Existing geothermal energy development has mainly targeted shallow geothermal resources. However, shallow geothermal resources are eccentrically located so we can generate power at narrow area and obtain the limited amount of energy. On the other hand, geothermal power generation using supercritical water is expected to increase power output with one power plant than the conventional geothermal power plants. Moreover, by constructing artificial reservoir, it becomes possible to introduce it in wide area and it is expected to contribute to reduction of development and attenuation risk. However, the feasibility of the geothermal power plants using supercritical water has not been fully investigated yet. In this research, we focus on artificial geothermal reservoir under supercritical environment, and quantitatively investigate its feasibility using numerical simulations. Specifically, artificial supercritical geothermal power generation with a downhole coaxial heat exchanger and a single U-shaped pipe method are considered as the heat exchanger method. We solve the unsteady thermal conduction problem using the finite-difference method with various flow rate and injection pressure conditions. As the result of numerical simulation, it was confirmed that in the case of both the double pipe system and the single U-shaped pipe, it is possible to extract supercritical water. Moreover, it was also found that high-performance heat insulating tubes are required for the inner pipe or the production well in either the double pipe type or the single U-shaped pipe type.

Keywords: supercritical geothermal power generation, numerical simulation, finite-difference method

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Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_32

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[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | A07 TOKYO BAY MAKUHARI HALL

[S-TT44] Airborne surveys and monitoring of the Earth

convener:Shigekazu Kusumoto(Graduate School of Science and Engineering for Research, University of Toyama), Takao Koyama(Earthquake Research Institute, University of Tokyo), Yuji Mitsuhata(AdvancedIndustrial Science and Technology), Shigeo Okuma(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Chairperson:Shigekazu Kusumoto, Takao Koyama(東京大学 地震研究所 火山センター), Shigeo Okuma(産業技術総合研究所), Yuji Mitsuhata(国立研究開発法人　産業技術総合研究所)

Airborne surveys are useful to better understand the whole and/or the detailed structures of the Earth and their variations. They can be implemented from a traditional manned and newly-developed unmanned aircraft to efficiently map very large or remote areas with difficult access. We invite studies on theory, instrumentation, processing, modeling or inversion and applications of airborne surveys.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[STT44-01] A Case Study on the Application of a Magnetic Survey Using Magnetometers Carried by Multicopter-type Drones

★Invited Papers

*Shiga Nobuhiko[1], Harada Haruo[1], Wada Kazushige[1] (1.Mitsui Mineral Development Engineering Co., Ltd.)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[STT44-02] Development for upgrading the generalization capability of the seismic damage detection of building based on the deep-learning utilizing aerial photographs

★Invited Papers

*Shohei Naito[1], Hiromitsu Tomozawa[2], Yuji Mori[2], Naokazu Monma[3], Hiromitsu Nakamura[1], Hiroyuki Fujiwara[1] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Mizuho Information and Research Institute, Inc., 3.Pasco Corporation)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[STT44-03] The resistivity distribution under the ground on bedrock creep slopes in Kii mountain area by the airborne electromagnetic survey

*Atsuhiko Kinoshita[1,2], Yasutaka Tanaka[2], Wataru Sakurai[1], Taro Uchida[1], Koichiro Hayashi[3], Katsushi Kawato[4], Minoru Okumura[4] (1.National Institute for Land and Infrastructure Management, 2.Sediment Disaster Prevention Technology Center, Kinki Developing Regional Bureau, Ministry of Land, Infrastructure, Transport and Tourism , 3.OYO Corporation, 4.NIPPON ENGINEERING CONSULTANTS CO.,LTD.)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[STT44-04] Study of UAV photogrammetry toward efficiently grasping volcanic landform

*Yuichi Iwasa[1], Takeshi Matsushima[2] (1.department of earth and planetary sciences, graduate school of sciences, Kyushu University, 2.SEVO, Kyushu Univ.)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[STT44-05] Volcanic gas measurements using UAVs

*Takeshi Hashimoto[1], Akihiko Terada[2], Toshiya Mori[3], Ryo Tanaka[1] (1.Institute of Seismology and Volcanology, Graduate School of Science, Hokkaido University, 2.Volcanic Fluid Research Center, Tokyo Institute of Technology, 3.Geochemical Research Center, Graduate School of Science, The University of Tokyo)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[STT44-06] Repeated Drone Magnetic Survey over Usu Volcano, Hokkaido Japan

*Shigeo Okuma[1], Masahiko Makino[2], Tadashi Nakatsuka[1], Ayumu Miyakawa[1], Makoto Yanagida[3], Minoru Okumura[4] (1.Institute of Geology and Geoinformation, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 2.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 3.Hanshin Consultants Co., Ltd., 4.Nippon Engineering Consultants Co., Ltd.)

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*Shiga Nobuhiko[1], Harada Haruo[1], Wada Kazushige[1]

1. Mitsui Mineral Development Engineering Co., Ltd.

Recently, large radio-controlled helicopters have been successfully used to take magnetic measurements of active volcanoes due to their long cruising distance and large payload. On the other hand, in mineral exploration, multicopter-type drones can conduct successful surveys in spite of their shorter cruising distance by repeating a number of short-distance flights. The drones can be used for faster and more extensive reconnaissance magnetic surveys compared with land magnetic surveys, by flying at about 50m above ground level, with 100m of flight separation. The drones can also provide high-resolution results that cannot be acquired easily by manned airplanes or helicopters.

Since 2017, magnetic measurements have been taken by a drone as reconnaissance for a domestic gold exploration project survey, with a total flying distance of 680km so far. This type of drone is commercially available, with 5.5kg of payload. It carries an optical pumping magnetometer, a 4K camera, and a circuit board for data processing and telecommunications, among other equipment. It also has a hanging magnetometer sensor that is suspended from a single 2.5m Kevlar cable.

The TMI data quality has mostly been good, and the data repeatability is always satisfactory. Usually, the discrepancies at the intersecting points between regular flight lines and tie-lines are small enough to be negligible. And no magnetic influence of the drone has been found, so there has been no need to compensate for drone airframe magnetism. However, the optical pumping magnetometer has a dead zone in the incident angle of the input magnetic field. Because the magnetic sensor is suspended from the drone, measurements can sometimes be interrupted if the sensor is strongly shaken or tilted by the wind or by an abrupt change in the cruising speed.

Since 2017, we have been conducting drone magnetic surveys at an existing gold mine and surrounding area. As a result, a low magnetic zone was found around an outcrop of silica sinter with strongly silicified rocks. The location of the low magnetic zone coincides with the peak of the horizontal gravitational gradient strength in this area. The peak was interpreted to show the locations of faults, and the low magnetic zone was derived from the thermal demagnetization by hydrothermal fluids came up throuh the fault, which brought about mineralization and the silica sinter. Since the silica sinter and strongly silicified rocks were mineralized (Au:1g/t-- Ag:16g/t), an epithermal gold-silver deposit is likely to exist beneath the sinter area.

(Acknowledgement)
We would like to express our deep appreciation to Irving Resources Inc. for their valuable assistance for this survey and for their permission to use materials from their surveys in this presentation.

Keywords: magnetic survey, drone, mineral exploration

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Development for upgrading the generalization capability of the seismic damage detection of building based on the deep-learning utilizing aerial photographs

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1. National Research Institute for Earth Science and Disaster Resilience, 2. Mizuho Information and Research Institute, Inc., 3. Pasco Corporation

NIED has been developing the real-time damage estimation and identification system for use in supporting decision-makings for emergency responses. In this study, we developed the immediate damage detection method of buildings utilizing remote sensing images, by sequentially updating the result of the real-time damage estimation system as a complementary.

The image consists from images of multiple ortho-rectified vertical aerial photos taken soon after the 2016 Kumamoto earthquake, the 1995 southern Hyogo Prefecture earthquake, and the 2011 off the Pacific coast of Tohoku earthquake. By combination of these images, we constructed training data and the damage discriminant model which have high generalization performance.

First, we classified building damages into four levels by means of the visual judgment; LEVEL1: No damage, LEVEL2: slight damage, LEVEL3: moderate damage, LEVEL4: collapsed. Then we divided building types as wooden and non-wooden based on the shape of roofs. And we organized these as GIS data, utilizing the building polygon provided by the Geospatial Information Authority of Japan.

Next, we normalized the resolution of each photographs as approximately 20 centimeters per pixel, and regularized brightness of images utilizing cumulative sum of luminance histograms.

Subsequently, we acquired patch images of 80-pixels square which include the main part of a common residence from each photographs, then extracted total 311,281 patches including each building damage levels proportionally.

Furthermore, we developed the damage discriminant model based on the CNN referring the VGG, then trained this model with these patch images. By this model, a discrimination accuracy of validation data which extracted from 3 earthquakes except of training data indicates over 70% in each damage levels.

In this study, an output of discriminant result is produced as a 4 color image created by raster scanning as a unit of 80-pixels square and a stride width of 20-pixels. Then by overlapping of building polygons, we classify the damage level of each building based on the threshold value of area ratios. Additionally, we assumed the sum of LEVEL3 and LEVEL4 as the totally collapsed buildings, and the sum of LEVEL2 and LEVEL3 and LEVEL4 as the totally or partially collapsed buildings, on the basis of the comparison between the governmental inspection result and the visual judgment result with aerial photographs.

By these methods, the immediate damage detection of the extensive area with an aerial photograph is achieved. Besides, by application of the Bayesian updating method, the estimation result based on the distribution of ground motion can be updated into the higher precision.

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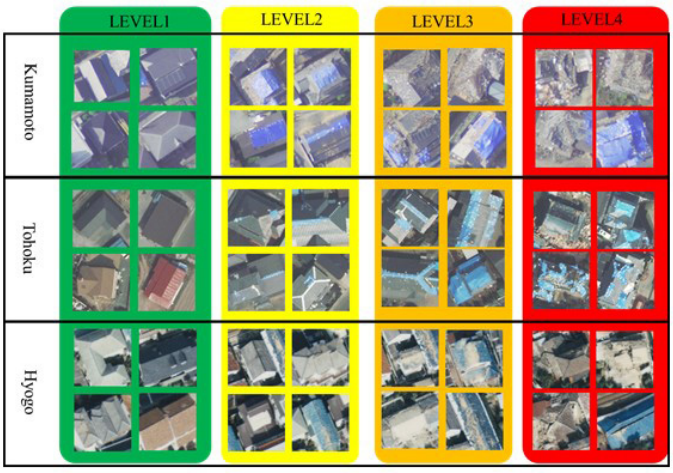
For all these reasons, the automatic damage detection with an aerial photo can approve the accuracy of the damage estimation based on the ground motion, and it is possible to utilize for disaster responses. However, this method has difficult tasks such as the damage discrimination based on a vertical image sometimes under-estimates the building damage except of wooden building which have tiled roof, and survey with optical images by airplane is difficult to observe during the cloudy weather and the night-time.

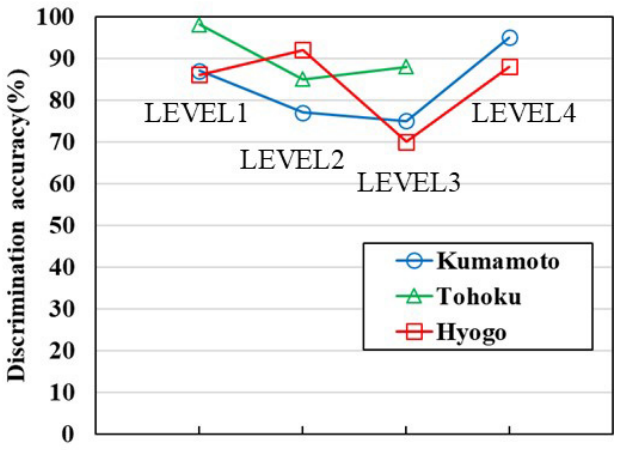
In the future, by utilizing the image acquired by different platforms and different sensors, we are going to develop the damage detection methods which have more immediacy and higher accuracy, then we intend to utilize these methods not only the initial disaster response, but also the recovery and reconstruction stage.

Acknowledgement:

This work was supported by Cross-ministerial Strategic Innovation Promotion Program (SIP), titled “Enhancement of societal resiliency against natural disasters”. We used the ArcGIS for developing training data, the OpenCV and the Python for image analyses, and the Keras as the deep-learning framework.

Keywords: Deep-learning, Convolutional Neural Network, Remote Sensing, Damage Detection, Aerial photograph, Bayesian Updating





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The resistivity distribution under the ground on bedrock creep slopes in Kii mountain area by the airborne electromagnetic survey

*Atsuhiko Kinoshita[1,2], Yasutaka Tanaka[2], Wataru Sakurai[1], Taro Uchida[1], Koichiro Hayashi[3], Katsushi Kawato[4], Minoru Okumura[4]

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In typhoon Talas of September 2011, numerous deep-seated landslides were occurred in the Kii Peninsula. In order to reduce the damage, it is necessary to grasp the dangerous slopes for landslides in advance. For the method to extract the dangerous slopes, there are a method using topography data such as the laser profiler, a method to judge from geology / topography, a method to judge from the amount of spring water at the end of slope and the quality of water. These methods have advantages and disadvantages, and there are insufficient aspects to estimate the degree of the danger and the scale of the dangerous slopes. Therefore, in order to complement these methods, we propose the method to estimate the risk and the landslide size based on the resistivity distribution of the ground obtained by the airborne electromagnetic survey. In this study, two bedrock creep slopes in the Akadani-west area were considered as the research fields and the validity of the estimation method was verified.
In this study, the vertical resistivity distributions of the slopes were created from the airborne electromagnetic survey obtained in the past. First, we calculated the average penetration depth from the frequency and the specific resistance of the ground. Next, the blank portion where data was not obtained was supplemented. Final, the smoothing processing was performed for the purpose of eliminating the noise. The vertical resistivity distribution of the ground is displayed in color, so it is easier to judge the danger level and estimate the slip surface. For this reason, we adopted the method of separating colors according to the frequency from all resistivity values obtained in the Akadani-west area.
In the slopes of the Akadani-west area, we have found that the resistivity value steeply changed in the vertical direction at the slip surface. For this reason, the degree of the landslide risk and the depth of the slip surface can be estimated from the resistivity distribution. In addition, we have found that the depth of the slip surface can be estimated in more detail by first differentiating the resistivity value in the vertical direction.

Keywords: Airborne electromagnetic survey, Resistivity distribution, Bedrock creep

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Study of UAV photogrammetry toward efficiently grasping volcanic landform

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In this study, we conducted three-dimensional modeling of volcanic landform using photogrammetry by UAV aerial photography with the aim of efficiently grasp landform. This method, which has been spread in recent years, can grasp landform as not points but planes, and it is thought that this observation can be conducted inexpensively, quickly, and without high-risks. In this study, aiming to make UAV observation efficient, we investigated relation between some factors of UAV observation and the accuracy of 3D model created.

We conducted mission flight on March and August 2018 at Kirishima Iwo-yama located Ebino city, Miyazaki prefecture. Iwo-yama erupted on April 2018, and landform change has occurred. We were able to get photogrammetric data before and after eruption. The UAV used on this study is DJI Mavic pro. The flying altitude from take-off point was 50 m, and the resolution of the images was 1.5 cm/pix. The photographed area was about 0.26 km2, and we set frontlap: the overlap of image along flight route, to 90 %, and sidelap: the overlap of image between flight routes, to 60 %. The UAV flew 60 minutes, and we got 1379 images during each flight. In addition, we measured 16 points as Check points and Ground Control Points (GCP): the points used as standard of coordinates, by GNSS and Total station.

Using Agisoft’ s software Photoscan, we created a three-dimensional model before and after eruption from images taken. By increasing a number of measured points, we got more accurate model than that of similar observation in 2017, On the other hand, there were partial vacancy on the model after eruption. This is probably because image processing was not successful due to a lot of volcanic gasses in the photographed image. For solving this problem, at next observation, we photograph from oblique angle in addition to vertical angle only around fumarole.

According to the above data, comparing models, we grasp volcanic landform change due to eruption on April 2018. Furthermore, we investigate relation between particularly GCP and the accuracy of 3D model in order to make UAV observation efficient.

This work was partly supported by MEXT under Integrated Program for Next Generation Volcano Research and Human Resource Development, and under Earthquake and Volcano Hazards Observation and Research Program. Also it was supported by ERI, The University of Tokyo under Joint Usage Program.

Keywords: UAV, photogrammetry, volcano

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Volcanic gas measurements using UAVs

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Volcanic gas is a mixture of volatile contents separated from magma and its composition may reflect the temperature and pressure conditions at a degassing depth, and the processes of phase change, interaction with rocks, and so on. In addition, since the ascent speed of volcanic gas is much larger than that of magma itself, it provides the earliest signals of subsurface processes such as the magma supply rate and/or the depth of the magma head. For this reason, volcanic gas composition is an important quantity to infer the current state of volcanic activity and to predict its transition in the future. In volcanic gas measurements, one of the conventional methods is the direct sampling and post-analyses in laboratory. However, such a direct sampling is often dangerous, especially when the volcano is erupting. In such a situation, measurements using UAVs are quite useful (Hashimoto et al., 2018). In this study, we review the recent progress in this research field, focusing on the case studies that we have been working on in these years.

Regarding the chemical composition, the Multi-GAS system is widely used, in which the sensors of some chemical species with a recording system are integrated into an apparatus and gas composition is directly measured on site. Recently, we made the apparatus smaller and lighter to mount on an unmanned aircraft. An electric-motor-type multi-rotor drone was used in the survey that was conducted two months after Mt. Ontake eruption in 2014 (Mori et al., 2016). This type of measurement can be done more easily in a field where we can use an engine-type compact unmanned helicopter that has much larger payload than small drones. In our experiment conducted in Noboribetsu, Hokkaido, we used the concentration meters of three gas species, which are relatively inexpensively available, and a thermo-hygrometer. We put them together in a net, hung it on an unmanned helicopter, and suspend it in the plume. The concentration ratios between CO_2, H_2S, SO_2, and H_2O were measured. At Kusatsu Shirane volcano, it has been proven that a trained researcher can perform similar operations with a drone.

With regard to gas emission rate, remote sensing of sulfur dioxide by an ultraviolet spectrometer is often used for volcano monitoring. The operation is normally performed on ground by driving a vehicle that mounts a measuring apparatus, looking the UV light in the sky. After the considerable miniaturization and weight reduction of the instruments in recent years, even an operation using a hobby-use drone has become possible (Tanaka and Mori, 2017).

In summary, volcanic gas measurements using UAVs are technically reaching a practical level. Further development in the research field is expected when the researchers acquire the operation skills of UAVs. We are also engaged in training and educational activities for improving such skills with the aid of the Next-generation Volcano Research and Human Resource Development Project by the MEXT.

Keywords: volcanic gas, chemical composition, drone, unmanned helicopter

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Repeated Drone Magnetic Survey over Usu Volcano, Hokkaido Japan

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1. Institute of Geology and Geoinformation, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 2. Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST), 3. Hanshin Consultants Co., Ltd., 4. Nippon Engineering Consultants Co., Ltd.

We have been developing a drone magnetic survey system using a portable magnetometer with a differential GNSS system (Okuma et al., 2018a). This time we employed a hexacopter with a diagonal axis distance of 995 mm and with a maximum payload of 5.7 kg (Okuma et al., 2018b). A main console of Geometrics G-858 Cs magnetometer, a NovAtel OEM615 GNSS receiver with its antenna and the GNSS data logger were attached to the drone. A Cs sensor was suspended from the drone by a string. We have tested flying attitudes and magnetic noise of the drone by changing a suspending length of the sensor cable. We concluded that an optimum cable length of our system was 0.85 m for surveys over rugged terrains because of the power of our drone. In this case, magnetic noise caused by the drone was estimated to be around 15 nT at the maximum by our experiments (Okuma et al., 2018b).

Using this drone magnetic survey system, we have conducted magnetic surveys over the Usu 2000 eruption area (Nishiyama craters area, Area A) and the southwestern flank of the main edifice of Usu volcano (Area B), Hokkaido Japan (Okuma et al., 2018b). In Area B, a curious magnetic anomaly had been observed by a previous helicopter-borne EM and magnetic survey in late 2000, which was flown at an altitude of 70–100 m above terrain along north–south survey lines and east–west tie lines, spaced 100 m and 1,000 m apart.

In May 2018, the drone surveys were flown at an altitude of 30 m above terrain along east–west survey lines (Area A) and north–south survey lines (area B), spaced 25 m apart. Total magnetic intensities were observed in every 0.1 seconds by the Cs magnetometer with GNSS positioning. According to data processing, the surveys were successful for mapping magnetic anomalies whose general pattern were well retrieved in the both areas, compared to known magnetic anomalies compiled from the 2000 survey.

Then, we applied the generalized mis-tie control method (Nakatsuka et al., 2009) to the magnetic anomalies of both 2000 and 2018 surveys in Area A and calculated temporal magnetic variations at crossover points. Although the survey specification of each survey was different, the result was successful to derive positive magnetic changes larger than 100 nT in and around intensive fumarolic areas of the 2000 eruption. The areas were characterized as apparent negative magnetic anomalies by the 2000 survey and are estimated to be underlain by Pleistocene volcanic rocks with reverse magnetization. Since the beginning of the eruption, the fumarolic activity gradually extended from the eruption center to the NNW along a ridge and lasted for several years. This implies that Pleistocene volcanic rocks constituting the area have been demagnetized by the strong fumarolic activity related to dyke intrusions at the 2000 eruption.

Based on the results above, it is concluded that drone magnetic survey is a promising method to derive long-term temporal magnetic changes and can play an important role to monitor volcanic activity.

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Keywords: Drone, UAS, UAV, Magnetic Survey, Repeated Magnetic Survey, Usu Volcano

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[J] Poster | S (Solid Earth Sciences)：S-TT Technology & Techniques

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_33

[S-TT44] Airborne surveys and monitoring of the Earth

convener:Shigekazu Kusumoto(Graduate School of Science and Engineering for Research, University of Toyama), Takao Koyama(Earthquake Research Institute, University of Tokyo), Yuji Mitsuhata(AdvancedIndustrial Science and Technology), Shigeo Okuma(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST))

Airborne surveys are useful to better understand the whole and/or the detailed structures of the Earth and their variations. They can be implemented from a traditional manned and newly-developed unmanned aircraft to efficiently map very large or remote areas with difficult access. We invite studies on theory, instrumentation, processing, modeling or inversion and applications of airborne surveys.

[STT44-P01] Development of an optical remote sensing technique for volcanic surface phenomena observation to estimate hyperspectral data from multispectral data

*Tetsuya Jitsufuchi[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[STT44-P02] Geomagnetic total intensity change before and after the eruptions at Shinmoedake volcano in 2018 detected by aeromagnetic surveys

*Takao Koyama[1], Takayuki Kaneko[1], Takao Ohminato[1], Atsushi Watanabe[1], Fukashi Maeno[1] (1.Earthquake Research Institute, University of Tokyo)

[STT44-P03] Droneborne resistivity mapping for a shallow ground investigation

*Yuji Mitsuhata[1], Tishiyuki Yokota[1] (1.AdvancedIndustrial Science and Technology)

[STT44-P04] Improvement test and field application applicability of airborne electromagnetic survey using drone

*Youichi Yuuki[1], Akira Jomori[2], Atsuyoshi Jomori[2], Takashi Kondoh[2] (1.Oyo corporation, 2.NEOSCIENCE)

[STT44-P05] Special Techniques for Airborne Laser Scanning Using Unmanned Helicopters

*Tomoya Hayakawa[1], Mio Kasai[2], Junro Imai[3], Akihiko Tani[4], Takatoshi Mikami[4] (1.NIPPON KOEI CO., LTD., 2.Hokkaido University Institute of Earth Surface Processes and Land Management, 3.YAMAHA MOTORCYCLE CO., LTD., 4.Obihiro Development and Construction Dept., Hokkaido Regional Development Bureau)

Development of an optical remote sensing technique for volcanic surface phenomena observation to estimate hyperspectral data from multispectral data

*Tetsuya Jitsufuchi[1]

1. National Research Institute for Earth Science and Disaster Resilience

Under the “Promotion Project for Next Generation Volcano Research B2:Development of remote sensing techniques for volcano observation, subtopic 2-2: Development of remote sensing techniques for surface phenomena of volcano”, the National Research Institute for Earth Science and Disaster Resilience (NIED) have been conducting a development of a visible multiband camera system to estimate hyperspectral data from multispectral data. This system consists of a 6 bans multi-band camera system and a spectrum estimation software that estimates dense spectrum information from sparse spectrum information from multi-band camera system. Modeling the relationship between hyperspectral data and multispectral data of igneous rock using multivariate analysis method, we have developed a spectrum estimation algorithm to estimate hyperspectral data from multispectral data for igneous rock sample. In this study, multiple regression analysis was applied to the hyperspectral and multispectral image data obtained by experiments of the volcanic rock samples, and we found this method can be used to estimate three hundred or more bands hyperspectral data from six bands multispectral data. We also develop the six band (six eyes) multi camera system for prototype of multi-band camera system for measuring the multispectral data required from our spectrum estimation algorithm. In this presentation, we descrive multivariate analysis results of hyperspectral and multispectral image data of six species volcanic rock samples for realizing a spectrum estimation algorithm and demonstrate hardware of six band (six eyes) camera system for our prototype of multi-bans camera system.

Keywords: hyperspectral image, multispectral image, multiple regression analysis, visible remote sensing, igneous rock

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Geomagnetic total intensity change before and after the eruptions at Shinmoedake volcano in 2018 detected by aeromagnetic surveys

*Takao Koyama[1], Takayuki Kaneko[1], Takao Ohminato[1], Atsushi Watanabe[1], Fukashi Maeno[1]

1. Earthquake Research Institute, University of Tokyo

As previous reports, so far, we have conducted aeromagnetic survey six times at Shinmoedake volcano after the 2011 eruption, and detected geomagnetic total intensity change by remagnetization due to cooling of lava in the main crater. According to a rate of change, thermal diffusion may be the main cause of cooling process.
Shinmoedake erupted again in March, 2018 and lava of 14Mm3 volume was accumulated in the main crater.
After the eruption, we conducted aeromagnetic survey again by using an unmanned helicopter. The geomagnetic total intensity change from the first survey in May 2011 is about 800 nTpp. Supposing a single dipole by magnetization of lava in the crater, a magnetic dipole moment is about 81MAm2. This value is bigger by 10MAm2 than a value inferred from a rate of change due to cooling of 2011 lava. Thus, this change is caused by magnetization of 2018 lava, which is abruptly cooled down at the surface and enhanced remagnetization.
Comparing the change of geomagnetic field in 2018 with one in 2011, however, a rate of change becomes about half. Supposed rock magnetization of 2018 lava is the same with one of 2011, a part of lava must demagnetize. It indicates that, at the 2018 events, the 2011 lava in the crater may be heated and some portions of it demagnetize.

Keywords: aeromagnetic survey, Shinmoedake

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Droneborne resistivity mapping for a shallow ground investigation

*Yuji Mitsuhata[1], Tishiyuki Yokota[1]

1. AdvancedIndustrial Science and Technology

Electromagnetic (EM) induction methods must be the powerful tools to map a resistivity distribution for the estimation of salinity and clay contents in soil and ground in civil engineering, environmental and agricultural investigations of shallow ground and soil. Usually, EM instruments are carried with hands and the measurement is carried out by walking to cover a survey area. However, it is not an efficient strategy for large survey areas. For such a situation, we propose a droneborne resistivity mapping.

We have applied a droneborne resistivity mapping in paddy fields and farms. To acquire good-quality data, we took care about the offset between a drone and an EM sensor, and the distance between an EM sensor and ground surface. As a result, the acquired data clearly show the difference between the paddy field and farm. This result must promise the further possibility of droneborne resistivity mapping.

Keywords: drone, electromagnetics, resistivity

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Improvement test and field application applicability of airborne electromagnetic survey using drone

*Youichi Yuuki[1], Akira Jomori[2], Atsuyoshi Jomori[2], Takashi Kondoh[2]

1. Oyo corporation, 2. NEOSCIENCE

Drone aerial electromagnetic survey method installs a transmission source on the ground and measures the induced magnetic field with a drone. The depth that can be investigated was up to 200 m in measurements so far. Drone airborne electromagnetic survey method can be applied to wide area survey in the future due to drone performance improvement. As a result, we carried out an improvement test of the exploration device and a field application test.
The device uses an induction coil as receiver, but the specification of the coil cannot measure the low frequency from the deep underground due to the restriction on the drone's operation. Therefore, we conducted experiments in Kusatsu-machi, Gumma Prefecture, using Magneto-Impedance (MI) sensors that can measure low frequencies. Experiment result confirmed that the MI sensor can measure the induced magnetic field from the drone.
Also, in order to know the limit of measurement using the induction coil, data was taken at a point about 900 m away from the transmission source. As a result, although it was measured on the ground, the induced magnetic field could be measured at a point of 900 m from the transmission source, and the depth of survey was 600 m.
It was confirmed that the drone airborne electromagnetic survey method could possibly be applied to deep survey in wide areas without using helicopters in the future. It is expected that the cost of the survey cost can be reduced, so that airborne electromagnetic survey can be utilized easily at more sites.

Keywords: airbonne electromagnetics, drone airborne electromagnetic survey, drone, MI sensor

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Special Techniques for Airborne Laser Scanning Using Unmanned Helicopters

*Tomoya Hayakawa[1], Mio Kasai[2], Junro Imai[3], Akihiko Tani[4], Takatoshi Mikami[4]

1. NIPPON KOEI CO., LTD., 2. Hokkaido University Institute of Earth Surface Processes and Land Management, 3. YAMAHA MOTORCYCLE CO., LTD., 4. Obihiro Development and Construction Dept., Hokkaido Regional Development Bureau

1. Introduction

In case of using the unmanned helicopters, we can scan elevation point data high frequency from 50-150m height. This practical method is developed a small unmanned helicopter owned by the Hokkaido Regional Development Bureau, through industry-university-government collaboration. Through these studies, we were able to verify the feasibility of all of these methodologies. In this paper, we discuss the special techniques that we employed with regards to airborne survey technologies, namely, installing antennas using a lift type vehicle, laser scanning from the air as well as discuss the equipment used and specific methods for performing these tasks.

2. Small unmanned helicopter specifications and survey location:

In this study, an autonomous unmanned helicopter (Yamaha RMAX-G1) owned by the Hokkaido Regional Development Bureau was used. During flight, the helicopter's remote controls were connected to the base station by radio, the flight route can be changed, the camera on the helicopter can be operated and the winch used to hang the sensor can be moved up and down when necessary. The helicopter's maximum flight time is roughly 90 minutes with a range of up to a 5 km radius from the base station. Its payload capacity is 10 kg at an elevation of 0 meters at 20ºC. It has actual track records of performing studies at an elevation of roughly 1,300 m carrying observation equipment of roughly 5 kg in weight.

In this study, the survey location was the Tottabetsu river, and set up a takeoff/landing 6 priod(2018.6) and 20 period(2018.10).

3. Installing antennas using a lift type vehicle:

Wireless transmission between the base station and the small unmanned helicopter consists of a 2.4 GHz data communication band for operations, and an analog 1.2 GHz band for camera images. Both bands require good visibility. In particular, when waves for the control system are blocked, the automatic return function will be activated and the survey will be discontinued. Trees may often not have a blocking effect, but we used a lift type vehicle to install both antennas higher than the tree. The lift type vehicle is the so-called "super deck" with a platform of approximately 2.5 ×1.5 m. It allows two people. With the use of this, we were able to assign both the antenna operator and visual helicopter watchperson at the high platform, and the antennas could be attached to the handrails.

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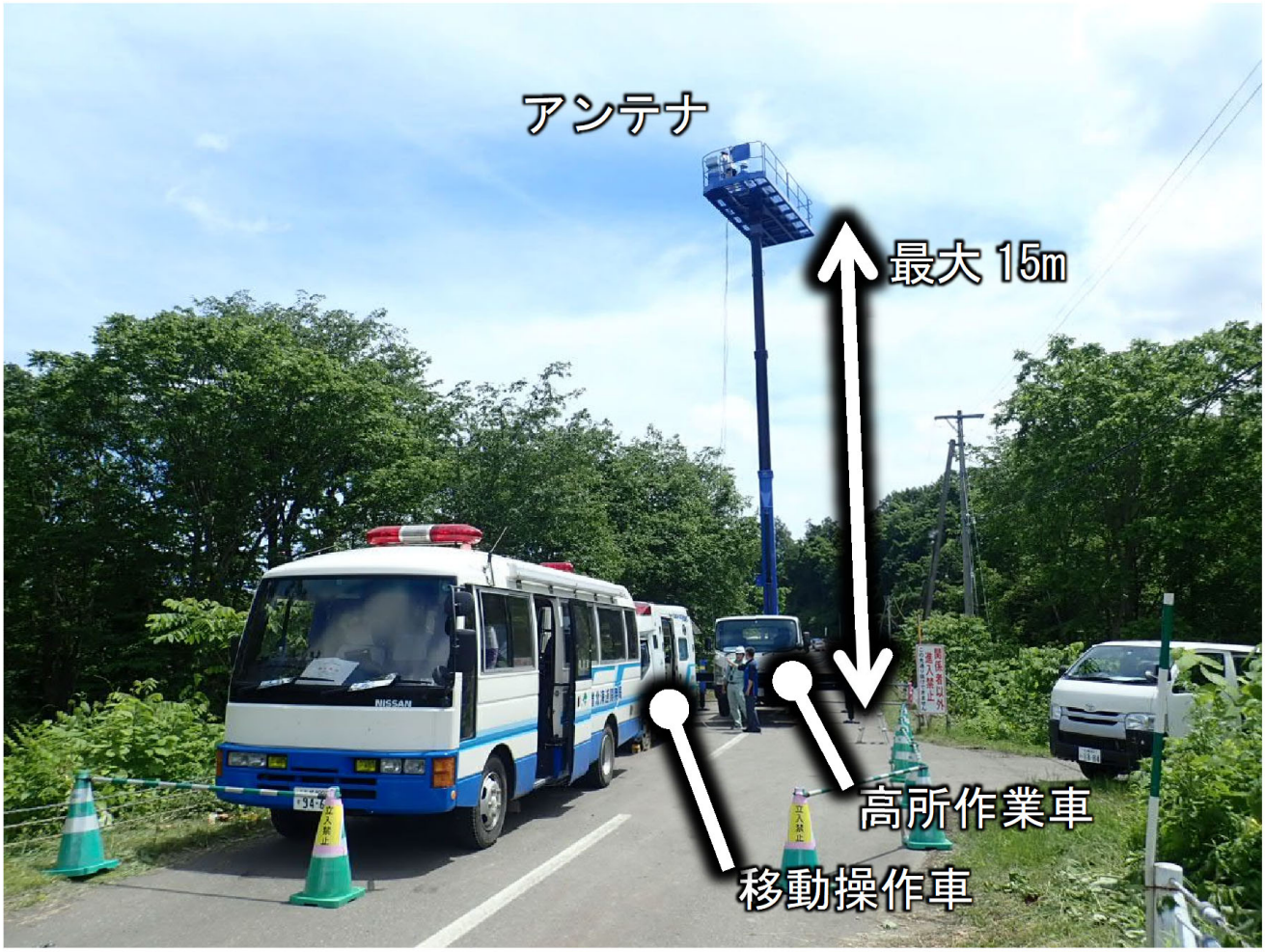
4. Laser scanning from the air:

We scan elevation point data using SkEyesBox owned by Yamaha Motorcycle co., ltd, while flying 50-70m height, 3-5m/s. We corrected position of the elevation point data using the method by the static data from Geographical Survey Instiude.

5. In closing:

In order to implement studies using unmanned helicopters, we will need to have command of these special techniques as part of our know-how and it will be important to implement regular training for staff involved in these studies.

Keywords: Unmanned Helicopters, Airborne Laser Scanning



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[J] Oral | S (Solid Earth Sciences)：S-TT Technology & Techniques

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 304 3F

[S-TT47] Creating future of solid Earth science with high performance computing (HPC)

convener:Takane Hori(R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology), Yuji Yagi(Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba), Katsuhiko Shiomi(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Takane Hori

Due to the development in computer science and computational science, large-scale or many times forward simulations and/or inversion analyses have become available recently. In solid Earth science, large-scale seismic wave propagation and crustal deformation with high fidelity models based on high resolution observation data have been demonstrated; uncertainty in crustal deformation caused by material properties and structures can be investigated based on many-time calculations for different material properties and structures; fault slip inversion analyses for non-Gaussian error distribution, etc. Thus, we will invite researchers who are applying HPC technology in forward simulations and inversion analyses and discuss how to improve more the collaboration between computer & computational sciences and solid Earth science. We are welcome submission by the researchers who are interested in this scope, especially students and young researchers.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[STT47-01] Expectations to more realistic Green's function with modeling errorfor the real-time estimation of the coseismic fault model

*Yusaku Ohta[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[STT47-02] Development of high-performance low order unstructured implicit finite-element solvers for solid earth science problems

★Invited Papers

*Kohei Fujita[1], Tsuyoshi Ichimura[1], Takuma Yamaguchi[1] (1.Earthquake Research Institute, The University of Tokyo)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[STT47-03] Optimal spectral element method for elastic wave computation

*Kei Hasegawa[1], Nobuaki Fuji[2], Kensuke Konishi[3] (1.Earthquake Research Institute, University of Tokyo, 2.Institut de Physique du Globe de Paris, 3.Institute of Earth Sciences, Academia Sinica)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[STT47-04] Multi scale tsunami simulation from earthquake initiation to tsunami run-up into the coastal area and high performance particle simulator

*Mitsuteru Asai[1], Mikito Furuichi[2], Daisuke Nishiura[2] (1.Kyushu University, 2.JAMSTEC)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[STT47-05] Digital-Ensemble Concept for Making Resilient Society against Natural Hazard

*Satoru Oishi[1] (1.RIKEN Center for Computational Science)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[STT47-06] Expected Role of High Performance Computing to Promote Earthquake Research

★Invited Papers

*Naoshi Hirata[1] (1.Earthquake Research Institute, the University of Tokyo)

Expectations to more realistic Green's function with modeling errorfor the real-time estimation of the coseismic fault model

*Yusaku Ohta[1]

1. Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University

Rapid understanding of the magnitude of large earthquakes and their associated fault dimensions are extremely important. Recently, Geospatial Information Authority of Japan (GSI) and Tohoku University are jointly developing the GEONET real-time analysis system (REGARD). REGARD system rapidly estimates two types of coseismic fault models, which are slip distribution along the plate interface and single rectangular fault model, using permanent displacement field based on the real-time GNSS time series. Currently, REGARD adopted the maximum likelihood approach to estimate the optimum model. The system, however, has problem to be improved. The current system is difficult to estimate the quantitative uncertainty estimation of the obtained result because of the estimated result should contain both of the observation error of the real time GNSS and modeling error caused by the model settings including uncertainty of the Green’ s function. Among them, the uncertainty of the Green’ s function is the most serious problem. Currently, REGARD adopted the simple elastic half-space model. It should cause the large estimation uncertainty in the coseismic slip fault model especially in offshore region whose structure is complex due to plate subduction. Thus, the more realistic Green’ s function with quantitative uncertainty will be needed. I will briefly introduce current development status of REGARD and show the expectations to more realistic Greens’ function with modeling error realized by Monte Carlo simulation using the HPC technology.

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Development of high-performance low order unstructured implicit finite-element solvers for solid earth science problems

*Kohei Fujita[1], Tsuyoshi Ichimura[1], Takuma Yamaguchi[1]

1. Earthquake Research Institute, The University of Tokyo

Problems in solid earth science, such as crust deformation problems and earthquake wave propagation problems, involve large problem sizes with complex 3D geometry and heterogeneous material properties. Use of implicit low-order finite-element methods on high-performance computers are expected to enable such analyses; however, these methods are not straightforward to attain performance on modern computer architectures due to heterogeneity of the problem. Thus, we have been developing algorithms and implementations to improve performance of low-order finite-element methods targeting recent CPU and heterogeneous supercomputer systems. In this talk, we will introduce our development for the CPU based systems (e.g., K computer, Intel Xeon-Phi Knights Landing based Oakforest-PACS) as well as heterogeneous systems (e.g. NVIDIA GPU accelerated Piz Daint and Summit), and show some application examples using these high-performance computing enhanced methods.

Keywords: finite-element method, high-performance computing

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Optimal spectral element method for elastic wave computation

*Kei Hasegawa[1], Nobuaki Fuji[2], Kensuke Konishi[3]

1. Earthquake Research Institute, University of Tokyo, 2. Institut de Physique du Globe de Paris, 3. Institute of Earth Sciences, Academia Sinica

We introduce new numerical integration operators which compose the mass and stiffness matrices of a modified spectral element method for simulation of elastic wave propagation. While these operators use the same quadrature nodes as does the original spectral element method, they are designed in order that their lower-order contributions to the numerical dispersion error cancel each other. As a result, the modified spectral element method yields two extra-orders of accuracy, and is comparable to the original method of one order higher. The theoretical results are confirmed by numerical dispersion analysis and examples of computation of waveforms using our operators. Replacing the ordinary operators by those proposed in this study could be a non-expensive solution to improve the accuracy.

*A significant portion of this presentation was published in Computer Methods in Applied Mechanics and Engineering (doi: 10.1016/j.cma.2018.07.025).

Keywords: Elastic wave, Numerical analysis, Finite-Element Method, Spectral Element Method, Error optimization, Computational seismology

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Multi scale tsunami simulation from earthquake initiation to tsunami run-up into the coastal area and high performance particle simulator

*Mitsuteru Asai[1], Mikito Furuichi[2], Daisuke Nishiura[2]

1. Kyushu University, 2. JAMSTEC

Due to future tsunami disaster prevention planning, it is strongly desired a simulation tool that accurately predicts possible damage level for structures and human resources in the inundation area. For the tsunami run-up simulation, we must calculate the crustal deformation as an input of the initiation of tsunami wave around the seismic fault. A stagger elasticity theory, in which homogeneous and spatial infinity is assumed to formulate the theory, is applied in practical and conventional crustal deformation estimation. The elastic theory cannot consider the heterogeneous crustal structure in space and the fracture propagation in time. Therefore, there is no guarantee that the conventional tsunami simulation estimates the largest possible inundation. In this paper, we conducted a series of disasters simulation from earthquake scenario, crustal deformation and tsunami propagation sequentially in order to discuss the necessity of consideration of seismic fault rupture propagation in tsunami simulation.

When modeling the entire city with a high fidelity particle model, one must deal with an enormous number of degrees of freedom, and implementation of highly parallel calculation is indispensable. In this paper, we developed a computational algorithm with high parallelization efficiency for the liquid spreading phenomenon over a flat plane problem, for later apply on tsunami run-up simulation. In particular, we propose an expanding slice grid method with a dynamic load balancer to utilize maximum efficiency on memory utilization and computational speed.

At the end of this paper, high fidelity tsunami run-up simulation in Kochi City by the Expanding slice grid method were conducted, and the utility of the proposed method was discussed.

Keywords: Tsunami, Crustal deformation, Large Scale Computation

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Digital-Ensemble Concept for Making Resilient Society against Natural Hazard

*Satoru Oishi[1]

1. RIKEN Center for Computational Science

In order to designing resilient society including developing or renovating cities, infrastructure management like making redundant route for not only transportation but also suppling water, energy as well as waste, we need digital-twin for simulating situations under catastrophic disasters. Digital-twin is a concept meaning “a virtual model of process, product or service and the paring of virtual and physical worlds allows analysis of data and monitoring of systems to head off problems before they even occur, prevent downtime, develop new opportunities and even plan for the future by using simulations”, according to Marr (2017). Previously, digital-twin concept was used for product manufacturing through computer aided engineering (CAE) to examining the performance and duration of target manufacture like rocket engine. Now, we are using the word for designing resilient society against natural hazard because designing resilient society requires paradigm shift of disaster mitigation strategy from “government saves public and it costs” to “private invests cities through market”. Private sectors require precise statistics of impacts of natural hazard for considering investment, however, we could not expect the quantitative impact without numerical simulation of large-scale disaster.

Large-scale disaster simulations consists of solvers and urban construction objects. Integrated Engineering System (IES) has both functions (Hori et al. 2018). There are several solvers for each kind of disasters like earthquake and tsunami. However, urban construction objects have been made one by one. Therefore, it is required to develop a tool that automatically generates the detailed construction objects of urban buildings for target cities. O-tani et al. (2014) have been developing such an automation tool, named Data Processing Platform (DPP), so that it can deal with multiple numerical simulations including tsunami inundation and evacuation, and seismic response analysis of ground and buildings. We have implemented a MPI-based parallelization of DPP, then it has generated objects of urban cities in the whole Japan which includes about sixty million buildings. Now, once given a certain appropriate ground property and motion, a simulation-based assessment of disasters can be achieved for the whole Japan.

Digital-twin of urban structures gives quantitative impacts of earthquake by putting expected seismic wave which has been calculated or monitored through the seismic simulation. Simulation of the earthquake impact by using the pair of the seismic wave and its probability revealed the risk of the society numerically. It changes the concept of fragility curve coming from extrapolation of experience to physics-based numerical simulation with multi-scenario. In other word, we assume digital-ensemble concept for numerically calculated risk of natural disaster which is required for our paradigm that private invests cities through market.

Marr, B. (2017): What is Digital Twin Technology -Why is it so important?, Forbes web site https://www.forbes.com/sites/bernardmarr/2017/03/06/what-is-digital-twin-technology-and-why-is-it-so-important/#50400e052e2a

Hori, M., Ichimura T., Wijerathne L., Ohtani H., Chen J., Fujita K., Motoyama H. (2018): Application of High Performance Computing to Earthquake Hazard and Disaster Estimation in Urban Area, Frontiers in Built Environment, DOI=10.3389/fbuil.2018.00001

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O-tani, H., Chen, J. and Hori, M. (2014): AUTOMATIC COMBINATION OF THE 3D SHAPES AND THE ATTRIBUTES OF BUILDINGS IN DIFFERENT GIS DATA, JJournal of Japan Society of Civil Engineers, Ser. A2 (Applied Mechanics), Vol.70 No.2, pp. I_631-I_639, DOI=10.2208/jscejam.70.I_631

Keywords: Digital-Ensemble, Resilient Society, Quantitative Risk Assessment

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Expected Role of High Performance Computing to Promote Earthquake Research

*Naoshi Hirata[1]

1. Earthquake Research Institute, the University of Tokyo

Headquarters for Earthquake Research Promotion (HERP) has been led earthquake observation, measurement, surveys and research in Japan for 20 years since the first 10-year basic comprehensive policy for the promotion set in April 23, 1999. During this 20 years, nation-wide basic observation networks have been established such as MOWLAS and GEONET. The observation data from the networks provide us rich information beneath Japan and are used by world-wide researchers discovering new phenomena such as slow earthquakes. On the other hand, data analysis methods and models, which are assumed in the analyses, are rather simple and not enough to extract rich information from the data. The necessity of the 3D realistic structure model for the data analyses has become clearer recently because of the ocean bottom observation data, such as the postseismic deformation of the 2011 Tohoku earthquake. To construct realistic model for the complex subduction zone in Japan, where two plates are subducting, large scale high-fidelity models are required and high performance computing is necessary to calculate crustal deformation and/or seismic wave propagation with the realistic models. For the next 10 years, we expect that high-performance computing will play an intrinsic role to promote earthquake research through higher level data analyses with realistic 3D structure in and around Japan. This will lead us a new stage in earthquake science.

Keywords: Headquarters for Earthquake Research Promotion, The basic comprehensive policy, Higher level data analyses

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[J] Poster | S (Solid Earth Sciences)：S-TT Technology & Techniques

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_20

[S-TT47] Creating future of solid Earth science with high performance computing (HPC)

convener:Takane Hori(R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology), Yuji Yagi(Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba), Katsuhiko Shiomi(National Research Institute for Earth Science and Disaster Resilience)

Due to the development in computer science and computational science, large-scale or many times forward simulations and/or inversion analyses have become available recently. In solid Earth science, large-scale seismic wave propagation and crustal deformation with high fidelity models based on high resolution observation data have been demonstrated; uncertainty in crustal deformation caused by material properties and structures can be investigated based on many-time calculations for different material properties and structures; fault slip inversion analyses for non-Gaussian error distribution, etc. Thus, we will invite researchers who are applying HPC technology in forward simulations and inversion analyses and discuss how to improve more the collaboration between computer & computational sciences and solid Earth science. We are welcome submission by the researchers who are interested in this scope, especially students and young researchers.

[STT47-P01] Prototype of Green's function library for geodetic slip inversion based on an integrated velocity structure model of Japan

*Ryoichiro Agata[1], Tsuyoshi Ichimura[2,3,4], Kohei Fujita[2,3], Takuma Yamaguchi[2], Takeshi Iinuma[1], Takane Hori[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, The University of Tokyo, 3.Center for Computational Science, RIKEN, 4.Center for Advanced Intelligence Project, RIKEN)

[STT47-P02] The Smoothed Particle Hydrodynamics on modern architectures

*Natsuki Hosono[1,2], Mikito Furuichi[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.RIKEN Center for Computational Science)

[STT47-P03] Development of Monitoring and Forecasting Methods for Crustal Activity Utilizing Large-Scale High-Fidelity Finite Element Simulations with 3D Heterogeneous Medium

*Takane Hori[1], Tsuyoshi Ichimura[2], Kohei Fujita[2], Takuma Yamaguchi[2], Ryoichiro Agata[1], Takeshi Iinuma[1] (1.R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology, 2.Earthquake Research Institute, The University of Tokyo)

Prototype of Green’s function library for geodetic slip inversion based on an integrated velocity structure model of Japan

*Ryoichiro Agata[1], Tsuyoshi Ichimura[2,3,4], Kohei Fujita[2,3], Takuma Yamaguchi[2], Takeshi Iinuma[1], Takane Hori[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Earthquake Research Institute, The University of Tokyo, 3. Center for Computational Science, RIKEN, 4. Center for Advanced Intelligence Project, RIKEN

Displacements and displacement rates on the earth’s surface obtained by means of geodetic observations such as Global Navigation Satellite System (GNSS), GNSS-Acoustic ranging technique, and ocean bottom pressure measurement help us understand how co-, post- and inter-seismic slip and/or slip deficit occur through inversion analyses. Recent researches revealed that it is important to incorporate heterogeneity of the elastic material properties and topography in such slip estimations, as geodetic stations used in the estimation are spatially widespread nowadays (e.g. Ichimura et al. 2013, Kyriakopoulos et al. 2013). In spite of these findings, the homogeneous half-space model (e.g., Okada 1992) is still usually applied to model the crustal deformation associated with the earthquakes in both academic studies and the national working groups of hazard estimations, because in part of the slightly complex procedures to introduce the features in the modeling. Furthermore, choice of the model settings associated with using the half-space model, such as plate geometry, consistency of the plate and the trench axis, and the coordinate projection method possibly degrades both transparency and efficiency of the studies. In this study, we propose a Green’s function library based on an integrated velocity structure model to account for these problems. In our framework, we convert the digital elevation model (DEM) data of the Japan Integrated Velocity Structure Model (Koketsu et al. 2008), which is currently one of the best-compiled velocity structure models in Japan, into a Cartesian coordinate system based on the reference ellipsoid of Geodetic Reference System 1980 (GRS80). In the Cartesian coordinate, we construct a finite element (FE) mesh of high fidelity to the converted DEM data using a structured-grid-based unstructured tetrahedral mesher (Ichimura et al. 2016). Based on the constructed FE mesh, Green’s functions for geodetic slip inversion are calculated using fast and scalable FE solver (Ichimura et al. 2014, 2016). Our final goal is to develop a Green’s function library of three focal regions of the subduction zones in Japan, namely, the Tohoku, Boso, and Nankai regions following the above manner. This hopefully will enable many studies to consider heterogeneous elastic material properties and topography in their geodetic inversion without being involved in complex modeling procedures, while maintaining transparency of the studies. We have calculated Green’s functions in the Tohoku region and applied to geodetic inversion of the 2011 Tohoku-Oki Earthquake (Iinuma et al., this meeting). The details of the framework and the prototype of the library will be presented in the poster.

Keywords: Geodetic slip inversion, Crustal deformation, Green's function, Finite element method

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The Smoothed Particle Hydrodynamics on modern architectures

*Natsuki Hosono[1,2], Mikito Furuichi[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. RIKEN Center for Computational Science

Numerical simulations of large-scale disasters, e.g., tsunamis, are important because such phenomena are difficult to carry out laboratory experiments.
Amongst several candidates for the numerical method, a particle-based numerical simulation method which is named Smoothed Particle Hydrodynamics (SPH) method is one of the most attractive methods.
In SPH, fluid is represented as a collection of hypothetical particles and governing equations for the fluid are converted into a sum of interactions between surrounding particles, which means that one SPH particle must interact with multiple numbers of particles.
This results in a large amount of memory access.

Note that architectures on which numerical simulations are performed are characterized by their B/F value, which is the ratio between the bandwidth and FLOPs.
For example, the B/F value for the post-K computer would be 0.5 and that for recent NVIDIA's GPUs is 0.1.
Note that the low-B/F value means that memory transfer limits the calculation speed.
Since SPH requires intensive memory access, a straightforward implementation of SPH on low-B/F architectures would result in low efficiency.
Hence, in order to effectively use such modern architectures, we need techniques to reduce the number of memory access in SPH.

In this work, we aimed at implementing an effective method to apply low B/F architectures to SPH.
We implemented the so-called ``multi-walk'' method to SPH.
The multi-walk method a method for particle-based methods to effectively use low B/F architectures.
We will report the predicted efficiency of our implementation on modern architectures, such as the K computer and NVIDIA GPUs.

Keywords: Numerical hydro dynamics

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Development of Monitoring and Forecasting Methods for Crustal Activity Utilizing Large-Scale High-Fidelity Finite Element Simulations with 3D Heterogeneous Medium

*Takane Hori[1], Tsuyoshi Ichimura[2], Kohei Fujita[2], Takuma Yamaguchi[2], Ryoichiro Agata[1], Takeshi Iinuma[1]

1. R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology, 2. Earthquake Research Institute, The University of Tokyo

To analyze crustal activity in the Earth's interior, such as spatio-temporal variation in slip velocity on the plate interface including ordinary and slow earthquakes, we need to use the data observed mostly on the Earth's surface. If the data are limited on land that is far from the deformation sources, it would be enough to use simple model as elastic homogeneous half space. However, it is becoming intrinsic to consider 3D heterogeneous structure of the interior, especially in subduction zones, since we can obtain dense surface deformation data on land and partly on the seafloor. Thus, to fully utilize such fruitful data, it is necessary to develop physics-based data analysis methods including (1) a structural model with the 3D geometry of the plate interface and the material properties such as elasticity and viscosity, (2) calculation codes for crustal deformation and seismic wave propagation using (1), (3) inverse analysis or data assimilation codes both for structure and fault slip using (1) and (2). To accomplish this, it is at least necessary to develop highly reliable large-scale simulation code to calculate crustal deformation and seismic wave propagation for 3D heterogeneous structure. Unstructured finite element (FE) non-linear seismic wave simulation code has been developed (Ichimura et al. [2015]). This achieved physics-based urban earthquake simulation enhanced by 1.08 T DOF x 6.6 K time-step. A high-fidelity FE simulation code with mesh generator has also been developed to calculate crustal deformation in and around Japan with complicated surface topography and subducting plate geometry for 1 km mesh (Ichimura et al. [2016]). This code has been improved for higher resolution in calculation of crustal deformation and achieved 2.05 T-DOF with 45 m resolution on the plate interface (Fujita et al. [2016]. This high-resolution analysis enables evaluation of change in the stress acting on the plate interface. For inverse analyses, a waveform inversion code for modelling 3D crustal structure has been developed (Ichimura et al. [2017]). Furthermore, such large-scale simulation codes have been implemented on a GPU cluster and analysis tools have been developed to estimate fault slip distribution with considering uncertainty in structural models (Yamaguchi et al. [2017a, 2017b]). Utilizing them, we are developing the data assimilation method for monitoring and forecasting the slip velocity variation on the plate interface with 3D heterogeneous structure.

Keywords: Earthquake forecasting, 3D heterogeneous medium, High fidelity

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[J] Poster | S (Solid Earth Sciences)：S-TT Technology & Techniques

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_34

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*Natsuki Hosono[1,2], Mikito Furuichi[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. RIKEN Center for Computational Science

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*Takane Hori[1], Tsuyoshi Ichimura[2], Kohei Fujita[2], Takuma Yamaguchi[2], Ryoichiro Agata[1], Takeshi Iinuma[1]

1. R&D Center for Earthquake and Tsunami, Japan Agency for Marine-Earth Science and Technology, 2. Earthquake Research Institute, The University of Tokyo

To analyze crustal activity in the Earth's interior, such as spatio-temporal variation in slip velocity on the plate interface including ordinary and slow earthquakes, we need to use the data observed mostly on the Earth's surface. If the data are limited on land that is far from the deformation sources, it would be enough to use simple model as elastic homogeneous half space. However, it is becoming intrinsic to consider 3D heterogeneous structure of the interior, especially in subduction zones, since we can obtain dense surface deformation data on land and partly on the seafloor. Thus, to fully utilize such fruitful data, it is necessary to develop physics-based data analysis methods including (1) a structural model with the 3D geometry of the plate interface and the material properties such as elasticity and viscosity, (2) calculation codes for crustal deformation and seismic wave propagation using (1), (3) inverse analysis or data assimilation codes both for structure and fault slip using (1) and (2). To accomplish this, it is at least necessary to develop highly reliable large-scale simulation code to calculate crustal deformation and seismic wave propagation for 3D heterogeneous structure. Unstructured finite element (FE) non-linear seismic wave simulation code has been developed (Ichimura et al. [2015]). This achieved physics-based urban earthquake simulation enhanced by 1.08 T DOF x 6.6 K time-step. A high-fidelity FE simulation code with mesh generator has also been developed to calculate crustal deformation in and around Japan with complicated surface topography and subducting plate geometry for 1 km mesh (Ichimura et al. [2016]). This code has been improved for higher resolution in calculation of crustal deformation and achieved 2.05 T-DOF with 45 m resolution on the plate interface (Fujita et al. [2016]. This high-resolution analysis enables evaluation of change in the stress acting on the plate interface. For inverse analyses, a waveform inversion code for modelling 3D crustal structure has been developed (Ichimura et al. [2017]). Furthermore, such large-scale simulation codes have been implemented on a GPU cluster and analysis tools have been developed to estimate fault slip distribution with considering uncertainty in structural models (Yamaguchi et al. [2017a, 2017b]). Utilizing them, we are developing the data assimilation method for monitoring and forecasting the slip velocity variation on the plate interface with 3D heterogeneous structure.

Keywords: Earthquake forecasting, 3D heterogeneous medium, High fidelity

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:shuhei Totsuka, Ayanori Misawa

Most of Earth's volcanism and much of its tectonic activity occur on and beneath the seafloor. Various phenomena on the seafloor are closely linked to plate tectonics, Earth and atmosphere. Seafloor rocks and sediments record Earth's evolution and heat and material fluxes on the Earth. Ocean Floor Geosciences session covers a broad range of research on LIPs, crustal movement and structure etc. Any fields of research and approach are welcomed. The session aims to encourage discussion among scientists from different study fields and to integrate our understanding of ocean floor.
The session is co-chaired by K. Tadokoro (Nagoya Univ.), O. Ishizuka (AIST), T. Toki (Univ. Ryukyus), and N. Takahashi (JAMSTEC).

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[SCG56-01] The restoration of precipitation record of iron hydroxide about seven years in Nagahama Bay, Satsuma Iwo-jima, Kagoshima.

*Naoya Sakamoto[1], Shoichi Kiyokawa[2] (1.Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[SCG56-02] Mineralogical and geochemical study of hydrothermal deposits beneath the seafloor at the Gondou field in the Okinawa Trough

*Shuhei Totsuka[1], Jun-ichiro Ishibashi[2], Kazuhiko Shimada[2], Kei Ikehata[3], Hideaki Machiyama[4], Koichi Iijima[4], Hirofumi Yamamoto[4], Hidenori Kumagai[4], Ken Ikehara[5], Toru Yamasaki[5], Yutaro Takaya[6], Toshiro Nagase[7], Thomas Tindell[8], Kotaro Yonezu[8], Yuki Tada[8] (1.Department of Earth and Planetary Sciences, Graduate School of Sciences, Kyushu University, 2.Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University, 3.Faculty of Life and Environmental Sciences, University of Tsukuba, 4.Research and Development Center for Submarine Resources, JAMSTEC, 5.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 6.Department of Resources and Environmental Engineering School of Creative Science and Enginerring, Waseda University, 7.Tohoku University Museum, 8.Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[SCG56-03] Strontium isotope study of sulfate minerals obtained by scientific drilling from seafloor hydrothermal fields in the Okinawa Trough

Akihi Tsutsumi[1], Naru Tsukamoto[1], Kazuhiko Shimada[1], *Jun-ichiro Ishibashi[1], Ryuichi Shinjo[2] (1.Department of Earth and Planetary Sciences, Kyushu University, 2.Faculty of Science, University of Ryukyus)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[SCG56-04] Numerical modeling of seafloor hydrothermal system in the Izena Caldron, Okinawa Trough

*Shohei Albert Tomita[1], Katsuaki Koike[1], Tada-nori Goto[1], Katsuhiko Suzuki[2], Takafumi Kasaya[2] (1.Graduate School of Engineering, Kyoto University, 2. Japan Agency for Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[SCG56-05] Electrical conductivity and spectral IP characteristics in the rock samples obtained in seafloor hydrothermal area and interpretation of them

*Yusuke Ohta[1], Tada-nori Goto[1], Katsuaki Koike[1], Weiren Lin[1], Koki Kashiwaya[1], Tadai Osamu[3], Takafumi Kasaya[2], Toshiya Kanamatsu[2], Hidenori Kumagai[2], Hideaki Machiyama[2] (1.Kyoto University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Marine Works Japan)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[SCG56-06] Geological structure north offshore Ishigaki-Jima estimated from seismic reflection survey

*Ayanori Misawa[1], Seishiro Furuyama[2,1], Masahiko Sato[3,1], Jih-Shin Chang[1], Takahiko Inoue[1], Kohsaku Arai[1] (1.Geological Survey of Japan, AIST, 2.Tokyo University of Marine Science and Technology, 3.The University of Tokyo)

The restoration of precipitation record of iron hydroxide about seven years in Nagahama Bay, Satsuma Iwo-jima, Kagoshima.

*Naoya Sakamoto[1], Shoichi Kiyokawa[2]

1. Department of Earth and Planetary Sciences, Graduate School of Science, Kyushu University, 2. Department of Earth and Planetary Sciences, Faculty of Science, Kyushu University

Satsuma Iwo-jima, located 38km south of Kyusyu island, Japan, is volcanic island in the northwestern rim of Kikai caldera. In Nagahama Bay the acidic mineral-rich hot springs cause various tonal changes of seawater. And oxidation of Fe^{2+} ions discolors the seawater into a reddish brown (Shigaura and Tazaki,.2001). This Bay is a semi-closed environment, iron hydroxide precipitation and deposition are likely to occur and precipitation rate of 33 cm/year. (Kiyokawa and Ueshiba, 2015). We restored the depositional record from10 m diameter and 1 m long acrylic plastic cores (total 50 core) that collected in Nagahama Bay from 2009 to 2018 (about 9 years). In this study, we revealed that the relationships precipitation of iron hydroxide and weather and seafloor environment in Nagahama Bay. the following studies were conducted: (a) Observation of sediment trap (CT image and observation of sediments using polarizing microscope and electronic microscope). (b) Meteorological observation and a survey of typhoon records in the past in Nagahama Bay. (c) Seafloor observation (Temperature in sediments and water pressure). By combining the sediment records in traps (34 Traps) from seven years from 2011, the stratigraphy of the total layer thickness of 5 m 70 cm was restored. From the CT image, it is divided into a high-density layer (iron hydroxide layer containing sand particles: 35 layers), a low-density layer (iron hydroxide layer: 28 layers), a high-density low-density alternate layer (7 layers) Seven thick high density - low density layer - high density low density alternate cycle was seen. Also, from the observation of smear slides and SEM, in the high-density layer, there are a structure in which iron hydroxide particles of about 100 μm aggregate to several μm, a volcanic glass of several tens to 200 μm, diatoms, the low-density layer mainly contains 50 nm of the iron hydroxide particles agglomerated to several μm in size. 37 typhoons approached or passed near Satsuma Iwo-Jima from June 2011 to September 2018. 17 of them were huge typhoons (Under 960hPa, over 30m/s). From meteorological data in Nagahama Bay, there were six Typhoon approached or passed between April 2018 and September 2018. When the typhoon passes south or west side of Satsuma Iwo-jima, it becomes south wind. The thick white layer was precipitated by the influence of the typhoon. So, the April to October the thick fine-grained sand layers and iron hydroxide layer precipitated due to typhoon. It is considered that fine-grained sand iron hydroxide alternating layers precipitaed in November to March without the influence of typhoon. When the typhoon passes south or west side of Satsuma Iwo-jima, it becomes south wind, Thick fine sand layer containing about 20 to 70% quartz and volcanic ash. Observed trap sediments, Trap sediments are composed iron hydroxide particles, and we consider that it is a chemical precipitation. The low-density layer excluding the high-density layer and the thickness of the alternating layer are recorded as iron hydroxide as the formation layer, and its layer thickness is 220 cm. The iron hydroxide accumulated on the Nagahama Bay (about 6000 m^2) in 7 years and it reached 13,200 m^3. As the interstitial water of this sediment is about 80%, the dry weight of iron hydroxide has reached 8,976 tons in seven years. And about 1282 tons of iron hydroxide were recorded in the formation every year in this Bay.

Keywords: Satsuma Iwo-jima, precipitation of iron hydroxide

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Mineralogical and geochemical study of hydrothermal deposits beneath the seafloor at the Gondou field in the Okinawa Trough

*Shuhei Totsuka[1], Jun-ichiro Ishibashi[2], Kazuhiko Shimada[2], Kei Ikehata[3], Hideaki Machiyama[4], Koichi Iijima[4], Hirofumi Yamamoto[4], Hidenori Kumagai[4], Ken Ikehara[5], Toru Yamasaki[5], Yutaro Takaya[6], Toshiro Nagase[7], Thomas Tindell[8], Kotaro Yonezu[8], Yuki Tada[8]

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The Gondou field is located at the western flank of the Daisan-Kume Knoll, at a water depth of 1330-1470 mbsl (meters below sea level). Many hydrothermal spire and mound structures were recognized in an area of ca. 1400 m ×400 m (Minami and Ohara, 2017). Previous study (Ishikawa et al., 2016) reported high Cu content in hydrothermal deposits collected from the Gondou field. Scientific drilling was performed by J-MARES during the SIP Integrated Ocean Resource Surveying System JM17-04 Cruise from October to November, 2017. Sediment cores were obtained from 5 Sites in Southern area of the Gondou field using BMS (Benthic Multi-coring System) installed on *Shincho-maru*. Mineralogical and geochemical studies of sulfide minerals in the obtained cores were conducted by microscopic observations, electron probe microanalyzer (EPMA) analysis, and X-ray diffractometer (XRD) analysis.
Massive and disseminated sulfide layers were recognized at Site GDUC06, which was covered with silty clay sediment and underlaid by silicified volcaniclastics. Two distinctive types of massive sulfide were recognized; the upper one is composed of sphalerite, pyrite, galena and associated with barite, while the lower one is composed of pyrite, chalcopyrite and associated with quartz, illite and chlorite. The underlaid silicified volcaniclastics layer includes pyrite. It is notable that formation of sphalerite-rich massive sulfide and chalcopyrite-rich sulfide is comparable to the black ore and yellow ore found in Kuroko-type deposits.
Similarity to the Kuroko-type deposits can be found in chemical composition of sulfide minerals. Iron content in sphalerite from the Gondou field ranges from 0.22 to 5.72 atm%, which would be comparable to the reported value from 0.07 to 0.35 atm% for the Matsumine and the Shakanai deposits of the Hanaoka mine, one of typical Kuroko-type deposits in the Hokuroku district (Shimazaki and Horikoshi, 1990)). Tetrahedrite-tennantite series occurred in the sphalerite-rich massive sulfide exhibit high As/(As+Sb) and Zn/Fe ratios, which are close to the range found in massive sulfide from the Hanaoka mine (Shikazono and Kouda, 1979). Since chemical composition of sulfide minerals is considered to reflect chemical condition such as f_{S2} during the formation, these similarities would provide keys to understand the mineralization processes.

Acknowledgements
This study is conducted under the framework of the Next-Generation Technology for Ocean Resources Exploration Project, Cross-ministerial Strategic Innovation Promotion Program (SIP) by the Japanese cabinet office. We are thankful to J-MARES (Research and Development Partnership for Next Generation Technology of Marine Resources Survey) for providing sediment cores used in this study.

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Keywords: Submarine hydrothermal deposits, Back-arc basin

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Strontium isotope study of sulfate minerals obtained by scientific drilling from seafloor hydrothermal fields in the Okinawa Trough

Akihi Tsutsumi[1], Naru Tsukamoto[1], Kazuhiko Shimada[1], *Jun-ichiro Ishibashi[1], Ryuichi Shinjo[2]

1. Department of Earth and Planetary Sciences, Kyushu University, 2. Faculty of Science, University of Ryukyus

Since hydrothermal fields in the Okinawa Trough develop within sediment-rich geologic setting of a backarc rifting in the continental margin, significant fluid mineral interactions and fluid migrations are expected to occur within the sediment layer. We have demonstrated that pore fluid chemistry in the vicinity of active vents in these hydrothermal fields were represented by two distinctive components; one is entrained-seawater component and the other is hydrothermal component which has the same origin as the vent fluid. Sulfate minerals such as barite and anhydrite are known to occur abundantly in and around the hydrothermal fields, because they form by precipitation caused by encounter of these two components. Isotope ratios of Sr incorporated in these sulfate minerals would provide key information to understand these processes.

We studied barite and anhydrite occurred in sediment cores obtained from three hydrothermal fields, Aki Site at the Iheya North Knoll, Hakurei field at the Izena Hole and Gondou field at the western flank of Dai-san Kume Knol, in the mid-Okinawa Trough. The sediment cores were obtained by scientific drilling campaigns conducted in 2014, 2016 and 2017 under the framework of the Next-Generation Technology for Ocean Resources Exploration Project. Determination of Sr isotope ratios was conducted employing LA-ICP-MC-MS (laser ablation inductively couple plasma multi-collector mass spectrometry) technique, which enabled multi-point measurement of a single mineral crystal or mineral aggregate using a polished section. Using the same polished section, Sr/Ba ratio of barite or Sr/Ca ratio of anhydrite was determined by EPMA (electron probe micro analyzer) analysis.

Strontium isotope ratios of anhydrite in all three fields were close to that of the present-day seawater with a few exceptions. Strontium isotope ratios of barite showed wider ranges biased from that of the seawater. Higher $^{87}Sr/^{86}Sr$ ratios are recognized in Hakurei field while lower $^{87}Sr/^{86}Sr$ ratios in Aki site and Gondou field. Difference in Sr isotope ratio between barite and anhydrite is attributed to that barite precipitates from mixture of the hydrothermal fluid and seawater while anhydrite precipitates from heated-seawater. As supportive evidence for this idea, we confirmed Sr isotope ratio in the sediment core from Hakurei field agreed with the reported value of barite in an inactive chimney-shape sulfide/sulfate breccia had been collected. Occurrence of barite in limited layers whereas common occurrence of anhydrite in the sediment core would be attributed to a result of subseafloor migration of the hydrothermal fluid.

Acknowledgements

This study was conducted under the framework of the Next-Generation Technology for Ocean Resources Exploration Project, Cross-ministerial Strategic Innovation Promotion Program (SIP) funded by the Japanese cabinet office. A part of the sediment cores used in this study were provided from J-MARES (Research and Development Partnership for Next Generation Technology of Marine Resources Survey).

Keywords: Seafloor hydrothermal activity, seafloor massive sulfide, LA-ICP-MC-MS, subseaflor fluid migration

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Numerical modeling of seafloor hydrothermal system in the Izena Caldron, Okinawa Trough

*Shohei Albert Tomita[1], Katsuaki Koike[1], Tada-nori Goto[1], Katsuhiko Suzuki[2], Takafumi Kasaya[2]

1. Graduate School of Engineering, Kyoto University, 2. Japan Agency for Marine-Earth Science and Technology

Regional heat flow measurements in the Izena Caldron and detailed heat flow measurements in the Jade hydrothermal field situated on the NE slope of the Izena Caldron were conducted by Kinoshita et al. (1997). They clarified that an enormous heat flow variation (10^{-1} to 10^{2}W/m^2) in the Jade site. In addition, near the Jade black smoker, the heat flow varies from >30W/m^2 at a hydrothermally altered area to 1.7W/m² within 100m distance from it. From large-scale heat flow measurements, 500m-wide rectangular zone (hereinafter called “Corridor”) with high heat flow (>1W/m^2) along the NE suggests the existence of linear heat source under the Corridor. In the research cruise of CK16-05, drilling and temperature measurements using Thermo Label were conducted in the Hakurei site, hydrothermal area of southern part in the Izena Caldron, and high temperature over 290℃ was measured at C9026. Although many heat flow data were obtained in the Izena Caldron, no heat flow data was obtained in the Hakurei site. Therefore, in this study, we conducted dense heat flow survey at 11 points with 550m measurement length and 50m measurement interval along EW direction in the Hakurei site in the research cruise of KM18-08C in September 2018. Moreover, we conducted a numerical simulation of multi-phase fluid flow using TOUGH2 to reveal distribution of physical properties and hydrothermal fluid flow pattern in the seafloor hydrothermal systems in a back-arc basin.

Heat flow value is calculated as the product of temperature gradient and thermal conductivity. In this study, we obtained temperature gradient values on the seafloor using a stand-alone heat flow (SAHF) meter operated by ROV. In the simulation, the size of study area was defined as 4.8×5.6×1.7 km and the seafloor was set as the top boundary where the temperature and pressure were fixed at 4 ℃ and hydrostatic condition, respectively. As the initial condition, we assigned the hydrostatic pressure, the average thermal gradient 0.16 ℃/m around the Izena Cauldron except for the hydrothermal area, and physical rock properties by referring to the borehole data. The values of discharge rate, mass in rate, and permeability (k) were adjusted appropriately through trial and error. As the geologic settings, we set conduits with $k = 1.0\times10^{-13}$m^2 under the discharge area of Jade and Hakurei sites and fault with k=3.0×10^{-14}m^2 under the Corridor along the vertical direction from bottom to surface, to realize the vertical flow of hydrothermal fluids from the deep part. In addition, caprock with k= 1.0×10^{-16}m^2 was located near the surface to generate the lateral hydrothermal fluid flow. Other places were set as volcanic rock with k= 1.0×10^{-14}m^2. Under these conditions, we simulated a natural state condition.

From heat flow measurements, we clarified very high heat flow (76W/m^2) at a 150m west site covered by mud from C9027, which suggests an existence of hydrothermal fluid flow beneath the seafloor at shallow part. In other places, the heat flow was varied from 3 to 12W/m^2. Through the simulation, a plausible large-scale temperature distribution and flow pattern were obtained. In terms of heat flow, by comparing the calculated and measured values along the Corridor and Hakurei site, the calculated values were conformed to correspond well with the measured values. According to the sensitivity analysis, the importance of caprock and conduit in the seafloor hydrothermal system was revealed. By a model without the conduit, the hydrothermal fluids did not ascend to the seafloor along the vertical direction and the tendency of measured heat flux could not be reproduced. Furthermore, by a model without caprock, heat cannot be preserved because it flows in all directions and the calculated heat flux did not accord with the observed flux. Consequently, the location and physical properties of the conduit and caprock were identified as the critical control factors on the accuracy of hydrothermal fluid flow simulation.

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Keywords: Izena Caldron, Numerical simulation, Seafloor hydrothermal system, TOUGH2, Heat flux

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Electrical conductivity and spectral IP characteristics in the rock samples obtained in seafloor hydrothermal area and interpretation of them

*Yusuke Ohta[1], Tada-nori Goto[1], Katsuaki Koike[1], Weiren Lin[1], Koki Kashiwaya[1], Tadai Osamu[3], Takafumi Kasaya[2], Toshiya Kanamatsu[2], Hidenori Kumagai[2], Hideaki Machiyama[2]

1. Kyoto University, 2. Japan Agency for Marine-Earth Science and Technology, 3. Marine Works Japan

Various geophysical explorations have recently been conducted in the seafloor hydrothermal field to estimate the scale of the seafloor massive sulfide. However, information obtained from geophysical exploration is limited. Therefore, in order to interpret the geological information under the seafloor based on the results of the geophysical exploration, it is necessary that the detailed analysis is carried out on hard-rock and sediment samples obtained on the surface and the lower of the seafloor, for comparing their features with results of geophysical exploration. In this study, we obtained rock samples in several hydrothermal fields; then we measured various physical properties and analyzed the chemical compositions, and we also investigated their relationship. As for physical properties, in particular, electric conductivity and spectral IP characteristics were investigated in detail. In samples with high electrical conductivity, some sulfide minerals, known to have high conductivity, were found to be contained. In spectral IP, some samples having a plurality of frequencies causing a peak in the phase difference of the voltage across the sample was observed. It is thought that this is due to the mixture of a plurality of sulfide minerals having different average particle sizes. In fact, in this study, we succeeded in reproducing the frequency characteristics of the sample by the rock physics model we constructed, assuming such characteristics. In the future work, we will study the consistency of the phenomena observed in this research and our new rock physics model through experiments on artificial samples using plural sulfide minerals of different particle sizes and types.

Keywords: Electrical conductivity, Spectral IP

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Geological structure north offshore Ishigaki-Jima estimated from seismic reflection survey

*Ayanori Misawa[1], Seishiro Furuyama[2,1], Masahiko Sato[3,1], Jih-Shin Chang[1], Takahiko Inoue[1], Kohsaku Arai[1]

1. Geological Survey of Japan, AIST, 2. Tokyo University of Marine Science and Technology, 3. The University of Tokyo

Geological Survey of Japan (GSJ), AIST conducted the marine geological survey cruise around the Ishigaki-Jima, Ryukyu Islands using R/V Hakurei (Japan Oil, Gas and Metals National Corporation) in August 2018. This cruise deployed high-resolution Multi-Channel Seismic (MCS) reflection, Multi-Beam Echo Sounder (MBES) swath bathymetry, gravity observation, and magnetic field observation. This presentation shows the geological structure around the Ishigaki-Jima based on MCS profiles, MBES swath bathymetry, gravity anomaly, and magnetic anomaly data.

Two remarkable unconformities are recognized in the sedimentary sequence offshore northward Ishigaki-Jima, separating the sedimentary sequence in the slope region into three layers. In the offshore northward Ishigaki-Jima, northwestward-dipping normal faults are recognized at the NE-SW trending geomorphic lineament. Developments of normal faults suggest the involvement of the extensional stress associated with the back-arc lifting of the Okinawa Trough. Since one remarkable unconformity is recognized in the sedimentary sequence in the Okinawa Trough, separating the sedimentary sequence into two layers. West of the Ishigaki Knolls, many of ENE-WSW trending normal faults are recognized. These normal faults are appearing clearly on the seafloor and are identified as ENE-WSW trending lineaments. Along with the development of normal faults, the depression-like morphology is formed from the Ishigaki Knolls to westward in the Okinawa Trough. We consider that the depression-like morphology bounding the ENE-WSW trending normal faults are the most recent structural feature. In this presentation, we will show the latest results of 2018 survey cruise and discuss the origin of the depression-like morphology.

Keywords: Ryukyu Arc, Ishigaki-Jima, Okinawa Trough, Normal fault, submarine volcano

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Keishiro Azami, Erika Tanaka

Most of Earth's volcanism and much of its tectonic activity occur on and beneath the seafloor. Various phenomena on the seafloor are closely linked to plate tectonics, Earth and atmosphere. Seafloor rocks and sediments record Earth's evolution and heat and material fluxes on the Earth. Ocean Floor Geosciences session covers a broad range of research on LIPs, crustal movement and structure etc. Any fields of research and approach are welcomed. The session aims to encourage discussion among scientists from different study fields and to integrate our understanding of ocean floor. The session is co-chaired by K. Tadokoro (Nagoya Univ.), O. Ishizuka (AIST), T. Toki (Univ. Ryukyus), and N. Takahashi (JAMSTEC).

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[SCG56-07] The first report of the evidence for hydrothermal activity in old oceanic plate

*Keishiro Azami[1], Shiki Machida[2], Naoto Hirano[3], Tetsu Kogiso[4], Yasuhiro Kato[1,2] (1.Department of System Innovation, School of Engineering, The University of Tokyo, 2.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 3.Center for Northeast Asian Studies, Tohoku University, 4.Graduate School of Human and Environmental Studies, Kyoto University)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[SCG56-08] X-ray computed tomography characterization of the distribution of biogenic apatite and sedimentary structures in pelagic clay around Minamitorishima Island, western North Pacific

*Yoichi Usui[1], Koichi Iijima[1], Hideaki Machiyama[1], Yuji Ichiyama[2,1], Erika Tanaka[3], Koichiro Fujinaga[4,3], Kazutaka Yasukawa[3,4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Chiba University, 3.The University of Tokyo, 4.Chiba Institute of Technology)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[SCG56-09] Geochemistry and distribution of REY-rich mud in the eastern off the Takuyo-Daigo Seamount within the Minamitorishima EEZ

*Koichiro Fujinaga[1,2], Kazutaka Yasukawa[3,1], Tatsuo Nozaki[4,2,1,5], Shiki Machida[1,2], Yutaro Takaya[6,2,1], Junichiro Ohta[1,2], Moei Yano[3], Ryo Shimomura[3], Erika Tanaka[3], Kazuhide Mimura[3], Koichi Horinouchi[3], Kenji Matsumoto[3], Yoichi Usui[4], Hirofumi Yamamoto[4], Kentaro Nakamura[3], Yasuhiro Kato[2,3,1], KM17-14C cruise members (1.Ocean Resources Research Center for Next Generation, Chiba Institute of Technology, 2.Frontier Research Centerfor Energy and Resources, School of Engineering, The University of Tokyo, 3.Department of Systems Innovation, School of Engineering, The University of Tokyo, 4.Japan Agencyfor Marine-Earth Science and Technology, 5.Department of Planetology, Graduate Schoolof Science, Kobe University, 6.Department of Resources and Environmental Engineering School of Creative Science and Engineering, Waseda University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[SCG56-10] Extended lateral correlation of deep-sea sediments around the Minamitorishima EEZ based on downhole variation of bulk chemical composition

*Erika Tanaka[1], Kentaro Nakamura[1], Kazutaka Yasukawa[1,2], Koichiro Fujinaga[2], Koichi Iijima[3], Shiki Machida[2], Yasuhiro Kato[1,2] (1.School of Engineering, The University of Tokyo, 2.ORCeNG, Chiba Institute of Technology, 3.JAMSTEC)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[SCG56-11] Tectonics of the abyssal basins surrounding the Ontong Java Plateau

*Masao Nakanishi[1], Shoka Shimizu[2], Daisuke Suetsugu[3], Takashi Sano[4] (1.Department of Earth Sciences, Graduate School of Science, Chiba University, 2.Department of Earth Sciences, Graduate School of Science and Technology, Chiba University, 3. Department of Deep Earth Structure and Dynamics Research, Japan Agency for Marine-Earth Science and Technology, 4.Department of Geology and Paleontology, National Museum of Nature and Science)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[SCG56-12] **The Cretaceous Normal Superchron: records from the Pacific, Indian and Atlantic oceanic crust**

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The first report of the evidence for hydrothermal activity in old oceanic plate

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A petit-spot monogenic volcano erupted on flexural part of lithosphere are reported from the world ocean [1]. Many of studies about petrology, geochemistry and geochronology of petit-spot volcanos had been done to understand their origin and nature of the asthenosphere. However, there has not been any studies about hydrothermal activity because nobody has ever observed in-situ eruption of petit-spot volcanos. As petit-spot volcanic activity ubiquitously occurs in the world ocean despite its small volume, the hydrothermal activity in petit-spot volcanos must be an important process for metal flux from seafloor to ocean.

During the cruise KS-18-9 of *R/V Shinsei-maru* in August 2018, we collected some ferromanganese oxides by dredge in offshore of Fukushima prefecture where simultaneously corrected basalts show youngest eruption in previously reported petit-spot volcanoes of NW Pacific (i.e. very few alteration of glass). The metal luster and massive texture of the ferromanganese oxides are typical features of hydrothermal origin. Hence, we defined geochemical and mineralogical features of the ferromanganese oxides using (μ)XRF, ICP-MS and XRD.

Based on the ternary plot of (Ce + Y + Zr) vs. (Ni + Cu) vs. (Mn + Fe), all samples are plotted into the area of hydrothermal origin[2]. REE patterns show negative Ce anomaly and low REE content which are character of hydrothermal origin[3] besides low La/Lu ratio as low temperature hydrothermal deposits rather than high temperature (~ 350 ℃) hydrothermal deposits. The samples contain 7 Åmanganate (birnessite), quartz, plagioclase and smectite. 7 Åmanganate indicates low temperature hydrothermal activity[4] as well. As the petit-spot volcanic activity is unique heat source for hydrothermal activity at the old oceanic plate (approximately 130 Ma). Otherwise, the hydrogenetic rim of some samples which are characterized by vernadite and enrichment of Cu and Ni implies cessation of the hydrothermal activity.

This is the first report of the presence of hydrothermal activity on an old oceanic plate in NW Pacific. The hydrothermal activity possibly occurred on the foot of petit-spot knolls because hydrothermal vents and mounds, and ferromanganese samples showing sign of hydrothermal have never been found during dives of submersible *SHINKAI 6500*[5], which explore along the slope of the knoll. Petit-spot volcanoes must be more simple hydrothermal system than others because of simple heat supply from a monogenetic eruption. Hence, it is the most suitable example to understand a complete process of single hydrothermal circulation. Detailed investigations by submersible *SHINKAI 6500* are highly required to define the hydrothermal system and the metal flux from petit-spot to ocean in the future.

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Keywords: Petit-spot volcano, Ferromanganese oxide, Hydrothermal activity

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X-ray computed tomography characterization of the distribution of biogenic apatite and sedimentary structures in pelagic clay around Minamitorishima Island, western North Pacific

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The apparent absence of visible sedimentary structures in pelagic clay often humpers their systematic classification into lithostratigraphy. On the other hand, large variation in biogenic apatite content in some pelagic clay has been recently recognized. Because the density of apatite is higher than the bulk of pelagic clay, the spatial distribution of apatite may be detected through physical properties to detect sedimentary structures. Biogenic apatite in pelagic clay hosts rare earth elements and yttrium (REY), so capturing their distribution is also important for resource exploration. Here we examine non-destructive X-ray computed tomography (CT) in comparison with chemical analysis of REY and P_2O_5 for piston cores obtained around Minamitorishima Island. The depth profile of CT-based density estimates matches well with the direct measurements of bulk density and gamma-ray attenuation data. The density profiles also show clear positive correlation with the REY and P_2O_5 profiles. Some deviation is attributed to the presence of micro Mn nodules, which show characteristic textural pattern on CT images and are easy to distinguish. Moreover, X-ray CT reveals the relationship between sedimentary structures and the distribution of biogenic apatite: biogenic apatite can be transported vertically by bioturbation (burrowing) for more than 30 cm, while there are thin (<10 cm) layers of high apatite content where burrowing is less severe. These features can be overlooked by visual inspections or conventional chemical analysis of discrete samples. Our results demonstrate X-ray CT as a rapid and complementary tool to study biogenic apatite apatite and REY distribution as well as sedimentary structures within pelagic clay.

Keywords: pelagic clay, X-ray CT, sedimentary structures

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Geochemistry and distribution of REY-rich mud in the eastern off the Takuyo-Daigo Seamount within the Minamitorishima EEZ

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In 2013, we discovered deep-sea sediment containing 400 –8,000 ppm of total rare-earth elements and yttrium (REY), which was termed “REY-rich mud”, within the Japanese exclusive economic zone (EEZ) around the Minamitorishima Island (Kato et al., 2013; Iijima et al., 2016; Fujinaga et al., 2016; Ohta et al., 2016; Nakamura et al., 2016; Takaya et al., 2018; Yasukawa et al., 2018). To clarify the mineralogical/chemical characteristics and distribution of the REY-rich mud in the Minamitorishima EEZ, we conducted nine research cruises over five years. During the KM17-14C cruise by *R/V KAIMEI* from December 16th, 2017 to January 7th, 2018, we investigated the distribution of the REY-rich mud in the eastern off the Takuyo-Daigo Seamount within the Minamitorishima EEZ, one of the most promising areas for REY-rich mud development. We collected five sediment cores by piston/gravity coring, and implemented bulk chemical analyses by using inductively coupled plasma quadrupole mass spectrometry (ICP-QMS) for trace and rare-earth elements, and X-ray fluorescence (XRF) for major elements. In this presentation, we report the sedimentological and geochemical features of the deep-sea sediments including REY-rich mud, and discuss the distribution of the REY-rich mud in the eastern off the Takuyo-Daigo Seamount.

Keywords: rare earth elements and yttrium (REY), REY-rich mud, deep-sea sediment, Minamitorishima Island, deep-sea mineral resources

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Extended lateral correlation of deep-sea sediments around the Minamitorishima EEZ based on downhole variation of bulk chemical composition

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Deep-sea sediments extremely enriched in rare-earth elements and yttrium (REY), showing up to 8,000 ppm of total REY concentration (ΣREY), exist within the Japanese exclusive economic zone (EEZ) near Minamitorishima Island in the western North Pacific Ocean [1, 2]. These deposits have stimulated interest as a new and highly promising mineral resource for REY. However, the number, occurrence depth and maximum ΣREY content of these REY-enriched layers appear to be quite variable, which makes it difficult to directly compare REY content peaks in different cores, and to investigate the geological factors controlling their formation and distribution.

Based on a careful consideration of a large geochemical dataset, we have recently recognized that deep-sea sediments within the Minamitorishima EEZ can be divided into nine types of stratigraphic layers, including three distinct REY peaks, with characteristic chemical compositions [3]. These layers deposited in a specific sequence and have lateral continuity in the Minamitorishima EEZ [3], which enables us to correlate the REY peaks in different cores.

In this study, we newly applied the chemostratigraphy to the piston core samples around the Minamitorishima EEZ collected by the MR16-07 cruise. The multi-elemental analysis suggests that the chemostratigraphy spreads out of the Minamitorishima EEZ and reaches at least ~500 km southeast of Minamitorishima Island.

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Keywords: REY-rich mud, chemostratigraphy, Minamitorishima Island, pelagic clay

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Tectonics of the abyssal basins surrounding the Ontong Java Plateau

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We present the tectonics of the abyssal basins that abut the Ontong Java Plateau using the resent geophysical investigations.

Ontong Java Plateau (OJP) is the largest of the major oceanic plateaus in the Pacific Ocean basin. OJP rises about 2 km above the surrounding deep ocean floor and has an area within the 4.5 km contour of about 1.8 x 10^6 km^2. A depth to the Moho discontinuity is more than 30 km (Gladczenko, 1994; Miura et al., 2004). The evidences from drilling samples indicate that most of the OJP formed rapidly about 122 Ma at mid-southern latitude in the Pacific Basin (Mahoney et al., 1993; Tejada et al., 1996, 2002). The widely accepted hypothesis of the formation of OJP is an emergence of a plume head (e.g., Coffin and Eldholm, 1993; Neal et al., 1997). The competing hypotheses are the mantle upwelling as the result of bolide impact (Ingle and Coffin, 2004) and the entrainment of dense fertile mantle by rapid seafloor spreading (Korenaga, 2005). Taylor (2006) proposed that the Ontong Java Plateau formed as a single large volcanic province together with the Manihiki and Hikurangi plateaus ca. 120 Ma, called Ontong Java Nui (Chandler et al., 2012). The OJP formation has been a major enduring problem of marine geology over the past more than 40 years. For settlement of the argument about the OJP formation, the tectonic setting of the abyssal basins around the OJP must be revealed.

Abyssal basins are contiguous withthe OJP: the Lyra Basin to the west, the East Mariana and Pigafetta basins to the north, the Nauru Basin to the northeast, and the Stewart and Ellice basins to the southeast. Tectonic histories of the Nauru, East Mariana, and Pigafetta basins, were revealed using the Mesozoic magnetic anomaly lineations (Nakanishi et al., 1992). Those of Lyra and Stewart basins are, however, still unknown because of lack of magnetic anomaly lineations.In at least three of these basins, the Nauru, East Mariana, and Pigafetta, Lower Cretaceous flood basalts overlie older oceanic crust (Abrams et al., 1993; Shipley et al., 1993; Nakanishi and Winterer, 1998).

To expose the tectonics of the abyssal basins around OJP, we conducted geophysical investigation in Nauru, Ellice, Stewart, and Lyra basins by R/Vs *Mirai*, *Kairei*, and *Hakuho-maru*. Our geomagnetic measurement western margin of Nauru Basin exposes the extension of magnetic anomaly lineations identified in Nauru Basin by Nakanishi et al. (1992). Our geophysical investigation in the Stewart Basin show the northeast-southwest rifting in the formation of the basin.

Keywords: Ontong Java Plateau, oceanic plateau, Pacific Plate

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The Cretaceous Normal Superchron: records from the Pacific, Indian and Atlantic oceanic crust

*Nobukazu Seama[1,2], Jerome Dyment[3], Taichi Sato[4,5], Yves Gallet[6], Kyoko Okino[7], Roi Granot[8], Yoshifumi Nogi[9], Nobutatsu Mochizuki[10], Toshitsugu Yamazaki[7]

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The Cretaceous Normal Superchron (CNS) is a ~40 Myr-long period extending between Chrons M0 and 34 (~120-83 Ma) during which the geomagnetic field polarity remained normal, although the possibility of some short reversed-polarity events cannot be ruled out. Systematic variations of the geomagnetic paleointensity have been suggested based on a deep-tow magnetic profile acquired in the Central Atlantic Ocean and selected sea-surface magnetic profiles worldwide crossing the whole CNS (Granot et al., *Nat. Geo.*, 2012). According to these authors, three sub-periods separated by two ubiquitous markers, Q1 and Q2, show successively moderate (M0-Q2), very dynamic (Q2-Q1) and very smooth (Q1-C34) geomagnetic paleointensity fluctuations. Here, we extend this study by using two additional data sets: a deep-tow magnetic profile acquired across the central, most dynamic part of the CNS in the South-Western Indian Ocean, and a set of sea-surface magnetic anomalies collected across two parts of the CNS in the Northern Pacific Ocean. These data sets are complementary. The high resolution of the deep-tow profiles is hampered by their uniqueness, with the risk to interpret spurious local effects as paleointensity variations. To alleviate this risk, we try to assess the two-dimensional character of the magnetized sources by analyzing vector magnetic data acquired during the South-Western Indian Ocean deep-tow survey. The advantage of the sea-surface Northern Pacific Ocean survey is the multiple profiles that can be compared and eventually stacked for a better signal/noise ratio. Unfortunately, the oceanic crust created during the CNS in the Northern Pacific Ocean displays a lot of anomalous volcanic seamounts. Again, we assess the two-dimensional character of the magnetized sources by analyzing vector magnetic data to avoid the effect of these seamounts. Only sea-surface magnetic profiles in the Northern Pacific Ocean have been collected ~5 km above the magnetic basement that results in much lower spatial resolution to compare to the ~1 km of the deep-tow profiles in the other area. But, the half-spreading rate there is 60-70 km/Myr, whereas it is ~30 km/Myr in the South-Western Indian Ocean and ~20 km/Myr in the Central Atlantic Ocean. This means that the time resolution of the deep-tow profiles becomes only about twice better than that of these sea-surface profiles in the Northern Pacific Ocean. We combine these data to evaluate the previous hypothesis of three sub-periods with distinct paleointensity signature within the CNS, assess the existence of the Q1 and Q2 markers, and tentatively build a more reliable geomagnetic paleointensity variation of the CNS.

Keywords: Cretaceous Normal Superchron, Geomagnetic paleointensity variation, Marine geomagnetic anomalies, Oceanic crust

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Chie Honsho, Tadashi Ishikawa

Most of Earth's volcanism and much of its tectonic activity occur on and beneath the seafloor. Various phenomena on the seafloor are closely linked to plate tectonics, Earth and atmosphere. Seafloor rocks and sediments record Earth's evolution and heat and material fluxes on the Earth. Ocean Floor Geosciences session covers a broad range of research on LIPs, crustal movement and structure etc. Any fields of research and approach are welcomed. The session aims to encourage discussion among scientists from different study fields and to integrate our understanding of ocean floor. The session is co-chaired by K. Tadokoro (Nagoya Univ.), O. Ishizuka (AIST), T. Toki (Univ. Ryukyus), and N. Takahashi (JAMSTEC).

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[SCG56-13] Offshore Postseismic Deformation of the 2011 Tohoku Earthquake Revisited: Application of an Improved GPS-Acoustic Positioning Method Considering Sloping Sound Speed Structure

*Chie Honsho[1], Motoyuki Kido[2], Fumiaki Tomita[3], Naoki Uchida[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions, Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University, 3.Graduate School of Science, Hokkaido University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[SCG56-14] Comprehensive analysis for the forearc structure and dynamics by using the S-net data

*Naoki Uchida[1], Ryosuke Azuma[1], Akira Ishigami[1], Tomomi Okada[1], Ryota Takagi[1], Genti Toyokuni[1], Norihito Umino[1], Yusaku Ohta[1], Makiko Sato[1], Syuichi Suzuki[1], Hidenobu Takahashi[1], Kazuya Tateiwa[1], Dapeng Zhao[1], Takashi NAKAYAMA[1], Akira Hasegawa[1], Ryota Hino[1], Satoshi Hirahara[1], Toru Matsuzawa[1], Keisuke Yoshida[1] (1.Research Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[SCG56-15] Shallow slow slip event inferred from GNSS-A seafloor geodesy

*Tadashi Ishikawa[1], Yusuke Yokota[2] (1.Hydrographic and Oceanographic Department, Japan Coast Guard, 2.Institute of Industrial Science, the University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[SCG56-16] Assessing strike-slip motion at the Shionomisaki Canyon along the Nankai oblique subduction zone using acoustic ranging system

*Motoyuki Kido[1], Eiichiro Araki[2], Takeshi Tsuji[3], Ryusuke Yamamoto[4], Yoshifumi Kawada[1] (1.International Research Institute for Disaster Science, Tohoku University, 2.JAMSTEC, 3.Dept. Earth Resources Engineering, Kyushu University, 4.School of Science, Tohoku University)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[SCG56-17] Development of seafloor realtime observation network for crustal deformation in the Nankai Trough: tiltmeter installation

*Eiichiro Araki[1], Takashi Yokobiki[1], Toshinori Kimura[1], Shuhei Nishida[1], Yuya Machida[1], Shuichi Kodaira[1] (1.Japan Agency for Marine-Earth Science and Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[SCG56-18] Calibration of the DONET pressure sensor network in the Nankai trough seismogenic zone using a mobile pressure gauge

*Yuya Machida[1], Shuhei Nishida[1], Toshinori Kimura[1], Eiichiro Araki[1] (1.Japan Agency for Marine-Earth Science and Technology)

Offshore Postseismic Deformation of the 2011 Tohoku Earthquake Revisited: Application of an Improved GPS-Acoustic Positioning Method Considering Sloping Sound Speed Structure

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One of the important issues on the GPS-acoustic (GPS-A) observation for sea bottom positioning is how to address the horizontal heterogeneity of the sound speed in oceans. We present an analysis method of GPS-A data in the presence of a sloping sound speed structure. By applying this method and revising the analysis scheme to make full use of existing data, we re-evaluated the horizontal postseismic deformations occurring ~1.5–5 years after the 2011 Tohoku earthquake. The revised horizontal movements have more uniform directions and rates between neighboring sites, suggesting enhancement of the array positioning accuracy. The revised displacement rate of the site on the incoming Pacific plate, located ~100 km northeast of the main rupture zone, was decreased significantly; it was only slightly, by 1.4 cm/year larger than the global motion of the Pacific plate, suggesting a relatively small effect of viscoelastic relaxation. The horizontal movements of the near-trench sites above the main rupture zone were generally landward and were significantly faster than the Pacific plate motion, indicating a viscoelastic relaxation of 5–10 cm/year. The distribution of the fast landward movements peaked near 38°N at an updip of the mainshock hypocenter and extended significantly farther to the north than to the south. This implies the existence of a secondary coseismic slip patch in the northern area in addition to a primary slip patch at ~38°N. The occurrence of episodic slow slip in early 2015 to the north of the main rupture zone was also verified from the GPS-A analyses.

Keywords: GPS-Acoustic observation, Postseismic deformation of the 2011 Tohoku earthquake

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Comprehensive analysis for the forearc structure and dynamics by using the S-net data

*Naoki Uchida[1], Ryosuke Azuma[1], Akira Ishigami[1], Tomomi Okada[1], Ryota Takagi[1], Genti Toyokuni[1], Norihito Umino[1], Yusaku Ohta[1], Makiko Sato[1], Syuichi Suzuki[1], Hidenobu Takahashi[1], Kazuya Tateiwa[1], Dapeng Zhao[1], Takashi NAKAYAMA[1], Akira Hasegawa[1], Ryota Hino[1], Satoshi Hirahara[1], Toru Matsuzawa[1], Keisuke Yoshida[1]

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The forearc area especially in the region under the Pacific Ocean is the frontier of the study on subduction zones. In this area, National Research Institute for Earth Science and Disaster Resilience (NIED) deployed the Seafloor Observation Network for Earthquakes and Tsunamis along the Japan Trench (S-net) which will open a new window to the Science on the structure and dynamics of the subduction zone. The 150 ocean-bottom cabled stations cover an offshore area of about 200 x 1000 km with a station separation of ~30 km perpendicular to the Japan and Kuril trenches and 50-60 km along the trenches. We obtained the continuous S-net velocity and acceleration seismograms from August 2016 to October 2018 which were made available by NIED in October 2018. We report first results of analysis that start with basic analysis of the data.

First, we estimated the direction of the three components of the sensors using the gravity and particle motion of teleseismic Rayleigh waves recorded by the accelerometers. The results show 1 degree or larger steps in the rotation about the axis of the cable for two earthquakes but stable for other periods. The directions of the axes were estimated with the uncertainty of 5 –10 degrees. The data was used to rotate waveforms of each station to N-S, E-W and U-D (Takagi et al., this meeting).

For the shallow structure, the thickness of sediments is estimated by using PS converted waves at the sedimentary basement. The PS-P traveltime difference shows a similar value of 1.3 to 1.5 s for most stations, which corresponds to a sediment thickness of 350-400 m. However, in the outer trench area of the Kuril –Japan trench junction and the inner trench area off Nemuro, thicker sediments are revealed (Azuma et al., this meeting). The cross-correlation analysis of ambient seismic noise suggests multiple velocities of ~1.5 km/s and ~0.3 km/s for 10 s or shorter periods. These two Rayleigh waves can be interpreted as the waves traveling in the sediments and Sea (Takagi et al., this meeting). The traveltime residuals of local earthquakes also suggest the effect of the shallow thin sediments. The P-wave travel time residuals for an existing 3-D velocity model exhibit variations of up to 2 seconds (Toyokuni et al. this meeting) and the residuals of near-shore earthquakes have up to 3 second for the outer trench areas (Okada et al. this meeting). These velocity structures are important for accurate hypocenter determinations (Okada et al. this meeting).

The deeper velocity structure is also investigated using the phase velocity of teleseismic and regional earthquakes. The teleseismic Rayleigh waves data result in a phase velocity of 3.6-3.9 km/s at periods of 20-50 s. The result shows relatively high wave speeds off Fukushima and Miyagi (Ishigami and Takagi, this meeting). The local earthquake tomography also shows a high P-wave speed in the overlying plate off Miyagi. The study also shows improvement of resolution in the offshore area by adding the S-net data (Toyokuni et al., this meeting). The cross-correlation analysis of ambient seismic noise has successfully extracted Rayleigh and Love waves at a period of as long as 30 s that travels among the S-net stations

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(Takagi et al., this meeting). The anisotropy of velocity in the overlying plate was also examined by shear-wave splitting measurements. The result shows trench parallel fast direction of shear waves, which is similar to the fast directions in the land area (Uchida et al., this meeting).

For the plate boundary, the repeating earthquakes are identified by the S-net which may contribute to a better understandings of the interplate slip and plate geometry (Uchida et al., this meeting). The accelerometer data of S-net also might have potential to detect slow fault slip in the offshore area, because some of the stations seem to responds to the Earth tide (Takagi et al., this meeting).

Acknowledgements: We thank the NIED staff who deployed the S-net, maintained the network and opened the data to the public.

Keywords: S-net, Subduction zone, Ocean bottom observation

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Shallow slow slip event inferred from GNSS-A seafloor geodesy

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In the subduction zone where mega thrust earthquakes occurs, many kind of slow earthquakes in deep plate boundary have been detected by terrestrial dense seismometer and GNSS monitoring networks. On the other hand, in the shallow part of the plate boundary, the investigation of slow earthquakes is limited because of the difficulty of observation at the ocean area. Due to recent development of observation technology, shallow slow earthquakes, such as LFE, VLFE and short-term SSE, have been detected by seafloor seismometers, ocean bottom pressure gauges and submarine borehole strainmeters (e.g., Yamashita et al.,2015; Wallace et al., 2016; Araki et al., 2017, Science).

Deep long-term SSE with duration over a few months is detected by terrestrial GNSS observation which is sensitive to long-term deformation. In this analogy, shallow long-term SSE can be detected by seafloor GNSS-A observation. However it was difficult to detect SSE with the capability of GNSS-A so far. Recently, we have been developing the GNSS-A technology to improve an observation frequency and precision (Yokota et al., 2017; Yokota et al., 2018). Then, the GNSS-A monitoring has a capability to reveals the occurrence situation of undersea SSE which could not be observed by the terrestrial GNSS.

However, because the accuracy is yet poor compared with GNSS, we have been investigating a method for detecting SSE from varying time series data. Nishimura et al. (2013) attempted to detect deep short-term SSE from GNSS data using AIC testing. We modified this method for GNSS-A data and attempted to detect shallow SSE. Then, we detected SSE signals from the GNSS-A data at off the Kii channel, Hyuga-nada and Kumano-nada which locate shallow side around the Nankai Trough historical seismogenic zone and strong coupling regions. There are various statistical method to detect transient variation from time series, and AIC is one example. It is necessary to consider further application of other statistical methods.

We also estimate the rectangle fault model using grid search that can explain displacements obtained from AIC method. Since the current observation sites are installed at 80 to 100 km intervals, displacements are detected only at 1 to 2 sites. Therefore, the estimated fault model has large uncertainty.

Keywords: GNSS-A seafloor geodesy, Slow slip event

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Assessing strike-slip motion at the Shionomisaki Canyon along the Nankai oblique subduction zone using acoustic ranging system

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Nankai trough is known as an oblique subduction zone, and may have trench-parallel strike slip motion along the extent of the outer ridge at least in geological time scale. Tsuji et al. (2014) pointed out that the right-lateral strike slip motion at least in geological timescale is evident from the offset at the Shionomisaki Canyon truncating the trench-parallel linearment. We installed short baseline acoustic ranging system at this site to measure a possible offset to reveal whether such displacement is steady state phenomenon or episodic one. We deployed three acoustic units forming a triangle array with a dimension roughly equal to the depth (~3000m) in 2016 and just have recovered in 2019. The total observation period reached to ~2 years before the batteries were exhausted. The southern baseline of the array is on the same segment, while the northern baseline crossing the trench parallel linearment obliquely. If there were any strike skip motion during our observation period, shortening should be observed only for the northern baseline. All of the three units were recovered in Shinsei-maru cruise (KS19-02), and we confirmed that all data, acoustic traveltimes for ranging, temperature and pressure for sound speed correction, were available properly. Preliminary analysis shows no significant shortening for both the baseline. However scatter is still large to identify the real signal due to large temperature fluctuation beyond the usual correction. More complicated temperature correction considering the time-difference among the three temperature data have to be applied to remove the noise before we conclude the result.

Keywords: Nankai Trough, Oblique subduction, seafloor acoustic ranging

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Development of seafloor realtime observation network for crustal deformation in the Nankai Trough: tiltmeter installation

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1. Japan Agency for Marine-Earth Science and Technology

Dense ocean-floor network for earthquake and tsunami in the Nankai Trough has been operational since 2010 monitoring earthquake and Tsunami activity in real-time in the seismogenic zone of Tonankai and Nankai earthquakes off Kii peninsula and off Shikoku Island of Japan.

The DONET observation system was designed so that new sensors may be added after deployment of the system, which is first utilized to connect deep borehole observatories deployed by IODP D/V Chikyu. The connection to the DONET enabled us to obtain continuous observation data and this led to discovery of repeating slow slip in the shallow part of the subducting plate (Araki et al., 2017). Currently, three such deep borehole observatories (C0002, C0010, C0006) are operational and providing borehole geodetic data in real-time. The sensitivity of the borehole to such slow slip events is significantly high and only these borehole can detect such repeating small slow slip events in the Nankai Trough. The distribution of the borehole observatories are not very suitable, though, to model area of observed slow slip, due to linear array of these three observatories. Wide spread of observatories sensitive enough to these slow slip events is crucial for such more detailed analysis of slow slip events.

Therefore, in addition to the deep borehole observatories, we plan to establish seafloor observatories that are sensitive to observe slow slip events, which can also be deployed and connected to DONET with lower cost. In our plan, the seafloor observatory (called seafloor observatory for crustal deformation) consists of tiltmeter deployed in shallow hole, fiber optic strainmeter, and seafloor pressure gauge.

We started construction of such seafloor observatories for crustal deformation in 2018. The first observatory is located east of the deep borehole observatory array (C0002, C0010, and C0006) near B-Node of DONET-1. We drilled 8.6 m borehole in October 2018 by R/V Kaimei and seafloor drill called BMS. We installed a Lily tiltmeter in February 2019 and connected the shallow hole tiltmeter to DONET via an interface box which will also be used to connect other sensors (seafloor fiber optic strainmeter and pressure gauge) in the future. The tiltmeter in the shallow hole was packed with sand to the top of the borehole to enhance stability of the tiltmeter in the hole. The initial data from the tiltmeter showed significant drift over 50 microradians a day, but appears to get stable gradually over a week period after the deployment. We analyze initial stabilization history of the shallow hole borehole tiltmeter to improve our installation technique in the future installation of tiltmeters in the seafloor.

We plan to complete installation of the observatory by adding fiber optic strainmeter and pressure gauge this year. Also, another observatory installation is planned in 2019 in DONET-2 area where JHD reported crustal deformation over a year in 2017-2018.

Keywords: the Nankai Trough, slow slip event, seafloor cable observatory

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Calibration of the DONET pressure sensor network in the Nankai trough seismogenic zone using a mobile pressure gauge

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Monitoring of long-time seafloor displacements in a dense and wide area in a seismogenic zone are key to understand strength of plate coupling related to occurrence of large interplate earthquakes. Precise pressure measurements on the seafloor have been thought to be useful tools for detecting long-time vertical seafloor displacements. However a pressure sensor has inherent instrumental drift at a maximum rate of 10 hPa/year. Therefore we need to calibrate each pressure sensor absolutely on the seafloor using high accuracy pressure gauge. Machida et al. (2017) has laboratory evaluated dependencies of temperature and pressure condition of quartz pressure gauge assuming a transport condition between laboratory and seafloor. Based on their results, we have developed a mobile pressure gauge for calibration of the seafloor pressure sensor (Machida et al., 2018, Nishida et al., 2019). The gauge is designed to decrease uncertainties of the quartz pressure sensor proposed by the Machida et al. (2018), and enables us to calibrate seafloor pressure sensor at accuracy of less than 1 hPa. We performed an in situ calibration of the DONET pressure sensor which are installed in the stations of 2C-10 and 1B-8 in October 2018 and February 2019, respectively. And we plan to recalibrate the DONET pressure sensor in May 2019, and estimate each drift component of the DONET pressure sensor. In the presentation, we show a first light of the calibration of the DONET pressure sensors, and a future plan for calibration of the DONET pressure sensors in the Nankai trough seismogenic zone.

Keywords: Mobile pressure gauge, DONET pressure sensor network, Calibration, Crustal deformation, Nankai trough

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | A05 TOKYO BAY MAKUHARI HALL

[S-CG56] Ocean Floor Geosciences

convener:Kyoko Okino(Atmosphere and Ocean Research Institute, The University of Tokyo), Chairperson:Misae Imano, Tetsuo No

Most of Earth's volcanism and much of its tectonic activity occur on and beneath the seafloor. Various phenomena on the seafloor are closely linked to plate tectonics, Earth and atmosphere. Seafloor rocks and sediments record Earth's evolution and heat and material fluxes on the Earth. Ocean Floor Geosciences session covers a broad range of research on LIPs, crustal movement and structure etc. Any fields of research and approach are welcomed. The session aims to encourage discussion among scientists from different study fields and to integrate our understanding of ocean floor. The session is co-chaired by K. Tadokoro (Nagoya Univ.), O. Ishizuka (AIST), T. Toki (Univ. Ryukyus), and N. Takahashi (JAMSTEC).

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[SCG56-19] Analysis of GNSS/Acoustic geodetic data including the period of the transponder replacement

*Ikuta Ryoya[1], Koto Mizuno[1], Horng-Yue Chen[3], Masataka Ando[2], Takeru Komi[1] (1.Faculty of Science, Shizuoka University, 2.Center for Integrated Research and Education of Natural Hazards, Shizuoka University, 3.Institute of Earth Science, Academia Sinica)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[SCG56-20] IPR (Indirect Path Ranging): a new approach for long-distance acoustic ranging with a moored relay node

*Ryusuke Yamamoto[1], Ryota Hino[1], Motoyuki Kido[2] (1.Graduate School of Science, Tohoku University, 2.International Research Institute of Disaster Science, Tohoku University)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[SCG56-21] Development of a kinematic GNSS-A positioning method using the extended Kalman-filter to detect precise vertical displacement

*Fumiaki Tomita[1], Motoyuki Kido[2], Chie Honsho[3], Ryo Matsui[3] (1.Graduate School of Science, Hokkaido University, 2.International Research Institute of Disaster Science, Tohoku University, 3.Graduate School of Science, Tohoku University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[SCG56-22] DOP-based accuracy evaluation of GNSS-A positioning on a drifting moored buoy quantified using sea trial observation data

*Misae Imano[1], Motoyuki Kido[2,3], Chie Honsho[3], Yusaku Ohta[3], Ryota Hino[3] (1.Graduate School of Science, Tohoku University, 2.nternational Research Institute for Disaster Science, Tohoku University, 3.Reserch Center for Prediction of Earthquakes and Volcanic Eruptions Graduate School of Science, Tohoku University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[SCG56-23] Analysis for GNSS/acoustic ocean bottom crustal deformation considering the heterogeneity of sound speed structure in ocean

*Natsuki Kinugasa[1], Keiichi Tadokoro[1], Yukihiro Terada[2], Teruyuki Kato[3] (1.Graduate School of Environmental Studies, Nagoya University, 2.National Institute of Technology, Kochi College, 3.Hot Springs Research Institute of Kanagawa Prefectural Government)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[SCG56-24] Seismic imaging using ocean bottom nodes in the Ishikari Basin, Japan Sea

*Tetsuo No[1], Takeshi Sato[1], Shuichi Kodaira[1], Satoshi Shimizu[2], Tetsuya Yokota[2], Karl Hosgood[3], Masako Robb[3], Tetsuro Tsuru[4] (1.JAMSTEC, 2.Nippon Marine Enterprises, 3.Emerson E&P Software, 4.Tokyo University of Marine Science and Technology)

Analysis of GNSS/Acoustic geodetic data including the period of the transponder replacement

*Ikuta Ryoya[1], Koto Mizuno[1], Horng-Yue Chen[3], Masataka Ando[2], Takeru Komi[1]

1. Faculty of Science, Shizuoka University, 2. Center for Integrated Research and Education of Natural Hazards, Shizuoka University, 3. Institute of Earth Science, Academia Sinica

In this study, we analyzed GNSS/Acoustic geodetic data including the period of the transponder replacement. The data were obtained 60km off Yilan, north eastern coast of Taiwan from May 2009 to May 2016. The site is located just south to the rifting valley in the western end of the Okinawa Trough back-arc basin. The GNSS/Acoustic measurements were conducted for four times from May 2009 to August 2012 and eight times from July 2012 to May 2016. Although the seafloor crustal deformation of the latter eight epochs has been already reported by Chen et al. [2018, GRL], the geodetic data of the former four epochs haven not been analyzed. This is because of a replacement of the seafloor transponders due to the battery depletion between former four epochs and latter eight epochs. Although the last observation of the former four epochs (August 2011) used three transponders, two of them did not reply to the acoustic ranging in July 2012 and then three transponders were newly installed instead. Therefore, the common transponder is only one between the former and the latter epochs. Generally in GNSS/Acoustic measurement, the centroid of the transponder arrays is regarded as a benchmark position which represents the seafloor motion. Because the centroids of the transponder arrays differ greatly between the former and the latter epochs due to the replacement, we cannot recognize these epochs as a continuous series of the observation. Thus We developed a new solution method to deal with the epochs with only a few common transponders as a continuous observation series. The new method solves not the centroid but the motion of the common transponders between different epochs directly. Solving only one configuration of the transponder array from the whole measurement data, the relative motion can be solved more robustly than solving the centroid independently for each epoch. We applied this method to the data and verified the continuity of the estimated benchmark motion comparing with a simulation. The simulation was conducted given an artificial transponder replacement based on the real data. As a result, when enough data are provided in each epochs, we can consider the former and the latter epochs as a continuous series of the observation with an error within 10cm in horizontal component. However, the result of the real data analysis generated about 40cm discrepancy between the former and the latter epochs. From the additional simulation, it was suggested that significantly small number of the acoustic ranging in the observation just before the battery depletion would affect the continuity of the benchmark position as well as the small number of transponders in the former epochs which was three instead of the four in the latter epochs. However, simulation also suggested that the motion of the benchmark within each epoch group before and after the replacement can be solved well. The solved benchmark velocity which is assumed to be same between the former and the latter is identical to the velocity reported in Chen et al. [2018, GRL]. This result suggests that there was no back-arc opening evet during the former epochs.

Keywords: Seafloor crustal deformation, GNSS/Acoustic measurement, Okinawa Trough

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IPR (Indirect Path Ranging): a new approach for long-distance acoustic ranging with a moored relay node

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Seafloor geodetic techniques such as GNSS-Acoustic measurement (GNSS-A), ocean bottom pressure-gauge (OBP) and direct path ranging (DPR) provide in-situ measurement of seafloor deformation. Especially, DPR is a specialized way to preciously measure relative horizontal motion continuously. It measures two-way travel time between a pair of acoustic transducers. The precision of DPR is typically 1–2 mm per 1 km baseline. Observation period is as long as ~3 years so far. However, difficulty in DPR is to ensure direct acoustic paths among transducers not interfered with seafloor as the distance being longer; e.g., an acoustic path bends downward by 142 m for 10 km baseline in a typical sound speed gradient. Unrevealed local topographic bump around the transducer often hinders paths, too.
In extricating such obstacles, we employed a new approach that uses an acoustic relay node, called interrogator, at the halfway of a baseline to reliably pass acoustic paths; we call it “Indirect Path Ranging (IPR)”. Sweeney et al. (2005, *Mar. Geod.*) introduced a ship-hanging interrogator ~500 m above the seafloor and reported that baseline length of 5 km can be measured with several centimeters precision. On the other hand, we moored the interrogator at midwater for long-term continuous observation. A moored interrogator is much advantageous than hanging type, which pumps according to ship's heave; displacement of the interrogator during individual ranging degrades the measuring accuracy.
IPR/DPR observation was conducted during October 2017–August 2018 off Fukushima region, where massive postseismic slip seems to be occurred in the shallow subduction zone (e.g., Iinuma et al., 2016, *Nature Comm.*). We installed five seafloor transponders at trench slope and moored an interrogator at the center of them (i.e., close to the trench axis). All the five baselines for IPR were available, while only one was available for DPR combination due to long distance. We confirmed that rangings were properly carried out over 80% of total period for IPR even the longest beseline of 9180 m.
As the first step, we estimate the 3-D position of the interrogator using four seafloor stations that can be simultaneously called from the interrogator. The interrogator was in motion within the radius of 50 m during most of the period, while it excursed by 300 m at the longest. Traveltime residuals were in order of ~10 cm in terms of distance. Since the acoustic paths were almost horizontal, vertical motion of interrogator may be poorly resolved. Therefore, the vertical motion should be determined form pressure data rather than being solved as an unknown. Anyway, uncertainty of the vertical position of the interrogator has less contribution in total ranging accuracy for its geometry. In the next step, we plan to evaluate interrogated baseline length changes with more precise interrogator position by applying sound velocity correction.

Acknowledgements: This research is supported by JSPS (Japan Society for the Promotion of Science) KAKENHI (JP26000002). The installation and recovery of the instruments were made during the research cruises of R/V Shinsei-maru (KS-16-14; KS-18-13), and R/V Hakuho-maru (KH-17-J02).

Keywords: Seafloor geodesy, Direct path ranging, Indirect path ranging, 2011 Tohoku Earthquake, Postseismic slip

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Development of a kinematic GNSS-A positioning method using the extended Kalman-filter to detect precise vertical displacement

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1. Background

GNSS-Acoustic (GNSS-A) seafloor geodetic observations have provided many observation results from campaign surveys using a research vessel (e.g., Tomita et al., 2017), and continuous surveys using a moored buoy has been tried recently (e.g., Kido et al., 2018). The classic GNSS-A positioning methods (e.g., Spiess et al., 1998; Kido et al., 2006) can provide a position for each ping simultaneously transmitted to all seafloor transponders; therefore, it is possible to perform real-time positioning. However, the classic method has been developed to detect horizontal motions, and it has not been well investigated to detect precise vertical motions. Meanwhile, Tomita et al. (2018) developed a kinematic GNSS-A positioning method using the extended Kalman-filter (EKF-based GNSS-A positioning method), and they demonstrated that vertical solutions could be improved. However, they has not been well investigated its improvement.

2. Numerical tests

We applied the EKF-based GNSS-A positioning method (Tomita et al., 2018) to simulation data. Here, we created simulation data based on three types of synthetic seafloor transponder arrangements, and we then investigated difference of precision of vertical solutions due to the transponder arrangements. As a result, for the transponder arrangements having diversity of shot angles from center of the array (multi-angled transponder arrangement), vertical positions can be solved even by the classic positioning method. Furthermore, the positioning precision can be improved by applying EKF.

3. Application to actual observation data

We applied the EKF-based positioning method to the actual observation data obtained by campaign surveys at sites with the multi-angled transponder arrangement in the off-Tohoku region (Tomita et al., 2017). Although vertical positions should not be changed with time during each campaign, the results showed long-term variation (~10 cm of standard deviation) by both the classic and the EKF-based GNSS-A positioning method. Since such long-term variations were similar to errors of the onboard kinematic GNSS positioning estimated by the means of Fujita & Yabuki (2003), it is expected that the GNSS-A positioning for the vertical component would be improved by improvement of the kinematic GNSS positioning. Meanwhile, we found that short-term temporal variation was improved by EKF. We calculated differential time-series of the solutions to remove the long-term errors, and we then calculated standard deviations of the differential solutions: ~10 cm and ~5 cm for the classic and the EKF-based positioning methods, respectively. Although we still have uncertainty in the long-term variation of the vertical solutions, precision for each acoustic ping can be greatly improved by EKF.

4. Investigation for real-time positioning

In order to implement EKF, we have to provide the appropriate process noise value. As we investigated the optimal process noise based on likelihood using the actual observation data of various campaigns, their values were similar each other; therefore, the appropriate process noise value can be fixed. The computation cost of the EKF-based positioning method is relatively low when the process noise value if

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fixed. Such low computation cost is plausible for the continuous survey using a moored buoy. Meanwhile, for the continuous survey, sampling frequency of the acoustic ranging is limited to save electricity of systems on the moored buoy and battery of the seafloor transponders. Then, we investigated effects of the sampling interval to the precision by re-sampling the observation data, and we found that difference of the precision between the classic and the EKF-based positioning methods was small for the sampling intervals longer than 30 minutes. Thus, to take advantage of the EKF-based positioning method, the sampling interval should be shorter than 30 minutes at least although much shorter sampling interval is plausible for precise positioning.

Keywords: Seafloor geodetic observation, Kalman-filter, Real-time positioning

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DOP-based accuracy evaluation of GNSS-A positioning on a drifting moored buoy quantified using sea trial observation data

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We have developed an offshore monitoring system of seafloor movement using a multi-purpose moored buoy, which realizes regular and on-demand GNSS-Acoustic (GNSS-A) measurements (Takahashi et al., 2014). The target accuracy of horizontal array position was set to 1 m, aiming to detect coseismic displacement accompanied with a huge earthquake (>M8). To endure the strong current around Japan, the system needs a slackly mooring technique for smaller tension (Ishihara et al., 2012) using a much longer tether line than the water depth. Because the moored buoy usually drifts by wind and current around a seafloor array, GNSS-A measurement is likely to be carried out far from the array center. However, the positioning accuracy significantly degrades when the observing point is positioned outside the array, due to a bad geometry between an observing point and transponders (Kido, 2007). Therefore, measurements using a moored buoy are generally carried out under worse conditions than those using a vessel. Our previous studies showed that the horizontal positioning accuracy (2 σ) with a single ranging was 46 cm when the buoy was inside the array, while it degraded to 97 cm when the buoy was outside the array, through a year-long sea trial near Nankai Trough (Imano et al., 2017; Kido et al., 2018). Besides the degradation depending on the distance from an observing point to the array center, we found a directivity of the positioning accuracy depending on the geometry between an observing point and seafloor transponders (Imano et al., 2018). In this study, we propose a method to evaluate the positioning accuracy at an arbitrary observing point based on the above characteristics of GNSS-A positioning using the system.

To interpret the accuracy degradation and directivity in relation to the position of observing points, we introduced Dilution of Precision (DOP: Langley, 1999) for GNSS-A positioning, which represents the degree of propagation of measurement errors to positioning errors. We firstly calculated EDOP/NDOP (the degree of error propagation to the EW/NS components of the array position) from the diagonal elements of the normal equation matrix of the observation equation of array positioning. Next, we computed error ellipses by diagonalizing the normal equation matrix because the nondiagonal elements were significantly large in many cases. The error ellipses clearly exhibit the feature that the estimation error of array positions was large in the direction from an observing point to the array center. Then, we converted the error ellipses to the positioning accuracy by multiplying the standard deviation of traveltime residuals when an array position was estimated using the data of all the 527 pings. The resulting positioning accuracy well explained the array position error and its dependency on the observing position found in the results of the sea trial.

The DOP analysis and its conversion into the positioning accuracy based on the actual observation data enable detailed assessment of the directional accuracy of GNSS-A positioning at arbitrary observing point, which is quite important in interpreting a realtime measurement of seafloor movement upon the occurrence of a huge earthquake. In this presentation, we will explain the above method and discuss its application to realtime GNSS-A positioning using the system assuming the occurrence of a huge earthquake.

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Acknowledgements: This study was supported by MEXT project for Development of GPS/Acoustic Technique, JST Cross-ministerial Strategic Innovation Promotion Program (SIP, Reinforcement of resilient function for preventing and mitigating disasters) and MEXT/JSPS Research Project for compound disaster mitigation on the great earthquakes and tsunamis around the Nankai Trough region.

Keywords: GNSS-A measurement, Moored buoy, DOP

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Analysis for GNSS/acoustic ocean bottom crustal deformation considering the heterogeneity of sound speed structure in ocean

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Observation for ocean bottom crustal deformation by GNSS (global navigation satellite system) acoustic method is monitoring long-term movements of transponders fixed on seafloor by acoustic ranging. We estimate the transponder position for each observation by vessel with the assumption that the relative position between transponders does not change temporally. Thus, precise estimation of the displacement needs having correct array shape.
The main factor of positioning error is temporal and spatial variation of travel time in ocean. Temporal variation is caused by the tide with a cycle of 12-24 hours and by the inertial gravity wave with a cycle of several 10 minutes. With the assumption that the transponder position is fixed during observation, the long-term variation can be estimated easily and the short-term variation cannot be cause of bias positioning error because its effect is included in the observed travel time as noise. The spatial variation is caused by the temperature, pressure, and salinity. The vertical gradient can be obtained by CTD (conductivity, temperature, depth profiler) measuring. Main factor of horizontal gradient is the temperature gradient which is generated significantly in the area near the Kuroshio current. We considered that the horizontal gradient has largest effect on the positioning. Then, we developed new estimation method considering both temporal and spatial variation of sound speed.
New method assumes that the horizontal sound speed structure has constant gradient. We applied this method to the observation point off the coast of Ashizuri and Kumano and compared the array shape estimated by new method and one considering only temporal sound speed variation. The result shows that the transponders where the sound speed is faster is estimated to be shallower. Making theoretical travel time small for the transponder where the sound speed is faster needs to make the propagation distance short. Since the ranging is operated on the circular route around the array, horizontal position cannot be biased to decrease the average of residual of travel time. That is why the position is estimated to be shallower. Thus, the accurate positioning needs considering the horizontal gradient of sound speed. We also discovered that the ship track has effect on its accuracy.

Keywords: Ocean bottom crustal deformation, GNSS/acoustic, Temporal and spatial variation, the Kuroshio current

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Seismic imaging using ocean bottom nodes in the Ishikari Basin, Japan Sea

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1. JAMSTEC, 2. Nippon Marine Enterprises, 3. Emerson E&P Software, 4. Tokyo University of Marine Science and Technology

In the Japan Sea, damaging earthquakes caused by faults distributed in land–marine transition zones and coastal areas (such as the 2007 Niigata-ken Chuetsu-oki Earthquake and the 1964 Niigata earthquake) have occurred in the past (e.g. Usami et al., 2013). Moreover, according to recent reports, source faults which may cause large earthquakes became apparent in many coastal areas of the Japan Sea (e.g. Committee for Technical Investigation on Large-scale Earthquake in Sea of Japan, 2014). Therefore, data acquisition regarding crustal structures in land–marine transition zones and coastal areas is an important task for increasing the accuracy of the source fault model in the Japan Sea. In previous studies, seismic surveys using ocean bottom cables and two-ship seismic surveys have effectively obtained deep structure imaging in land–marine transition zones and coastal areas of the Japan Sea (e.g. Abe et al., 2010; Sato, 2013). However, owing to budget constraints, such methods and systems may not always be feasible. Therefore, to facilitate future seismic exploration in coastal areas, we attempted a seismic survey using ocean bottom nodes (OBNs), an approach that employs easy-to-handle equipment.

For our seismic survey, we used the JAMSTEC R/V *KAIMEI* to study crustal structures off of the northwestern coast of Hokkaido, Japan (Sato et al., 2018). The OBN system was constructed by Nippon Marine Enterprises, Ltd, comprising 10 nodes at approximately 100-m intervals in the Ishikari Basin. The OBN system was installed at a water depth of 800 m. Each node had a natural frequency of 15 Hz and recorded data for three component omnidirectional geophones and one hydrophone component (Shimizu et al., 2012). The data acquisition specifications were as follows: shot spacing was 25 m; tuned air gun array had a maximum capacity of 2,650 cu in (approximately 43.5 L) and comprised 11 air guns; standard air pressure was approximately 2,000 psi (approximately 14 MPa); and the air gun array was kept 6 m below sea surface throughout the experiment. In this survey line, a normal multi-channel seismic reflection (MCS) survey and a seismic refraction survey using ocean bottom seismographs were also separately performed.

Our data analysis used a method based on mirror imaging. Wave field separation using geophone and hydrophone polarity characteristics and multiple reflection waves was performed together with prestack migration (Dash et al., 2009). Normal reflection imaging was performed using the upgoing wavefield, which reflected on the reflector once. However, mirror imaging was performed using the downgoing wavefield. Using this approach, the imaging range could be extended to several times that of the developed OBN system. Based on a preliminary analysis of the OBN data, we obtained imaging of the sedimentary layer and the basement below the seafloor; the obtained results are consistent with those of the normal MCS profile.

Keywords: Ocean bottom nodes, Seismic imaging, Japan Sea

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[J] Oral | S (Solid Earth Sciences)：S-CG Complex & General

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 304 3F

[S-CG62] Potentiality of Machine Learning in Solid Earth Sciences

convener:Takahiko Uchide(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST), Chairperson:Takahiko Uchide(Geological Survey of Japan, AIST), Hirokuni Oda

The recent development of the machine learning techniques including the deep learning is leading innovations in various fields. The applications of these techniques to solid earth sciences are also expected to develop new frontiers by, for example, the classification, the pattern recognition, and the regression of data. On the other hand, there are concerns on the human-interpretability of the deep learning.
This session will provide an opportunity to share the application studies to various fields in solid earth science and inspire each other. We also look forward to studies addressing the black box issue of the deep learning.

9:00 AM - 9:20 AM JST | 12:00 AM - 12:20 AM UTC

[SCG62-01] The Promise of Machine Learning in Solid Earth Geoscience: Examples from Seismology

★Invited Papers

*Gregory C Beroza[1], Mostafa Mousavi[1], Weiqiang Zhu[1], Karianne J Bergen[2], Paul A Johnson[3], Maarten V De Hoop[4] (1.Stanford University, 2.Harvard University, 3.Los Alamos National Laboratory, 4.Rice University)

9:20 AM - 9:35 AM JST | 12:20 AM - 12:35 AM UTC

[SCG62-02] Automatic Approach to Low-Frequency Earthquakes Detection in Southwest Japan Based on Deep Learning Technique

*Yu Junyu[1], Yuji Yagi[1], Takanori Matsuzawa[2], Ryo Okuwaki[1] (1.Graduate School of Life and Environmental Sciences,University of Tsukuba, Tsukuba, 2.National Research Institute for Earth Science and Disaster Resilience)

9:35 AM - 9:50 AM JST | 12:35 AM - 12:50 AM UTC

[SCG62-03] Broadband ground motion waveform synthesis utilizing AI-based upsampling technique (2)

*Takahiro Maeda[1], Asako Iwaki[1], Hiroyuki Fujiwara[1], Kazutoshi Matsuzaki[2], Hiromitsu Tomozawa[2], Yuji Mori[2], Misato Tsuchiya[2], Naofumi Miyata[2] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Mizuho Information & Research Institute, Inc.)

9:50 AM - 10:05 AM JST | 12:50 AM - 1:05 AM UTC

[SCG62-04] Forecast trial of postseismic deformetion after the 2011 Tohoku-Oki earthquake by recurrent neural network

*Norifumi Yamaga[1], Yuta Mitsui[2] (1.Graduate School of Science and Technology, Shizuoka University, 2.Shizuoka University)

10:05 AM - 10:25 AM JST | 1:05 AM - 1:25 AM UTC

[SCG62-05] Deep Learning Approaches for Eruption Prediction of Sakurajima

★Invited Papers

*Tsuyoshi Murata[1] (1.Tokyo Institute of Technology)

10:25 AM - 10:30 AM JST | 1:25 AM - 1:30 AM UTC

Discussion

The Promise of Machine Learning in Solid Earth Geoscience: Examples from Seismology

*Gregory C Beroza[1], Mostafa Mousavi[1], Weiqiang Zhu[1], Karianne J Bergen[2], Paul A Johnson[3], Maarten V De Hoop[4]

1. Stanford University, 2. Harvard University, 3. Los Alamos National Laboratory, 4. Rice University

Physical, chemical, and biological processes all have substantial influence on the solid Earth. They range over tremendous spatial and temporal scales and can interact in complex ways. Increasingly, humans interact with the shallow reaches of the Earth in ways that are increasingly consequential. The solid Earth presents a variety of natural hazards that are poorly understood, yet increasingly impactful as exposure grows through increasing urbanization in hazard-prone areas. We need to improve our understanding of how the Earth works; however, attempts to understand the solid Earth are challenging because nearly all of the Earth’ s interior is inaccessible to direct observation. Knowledge of the Earth's interior must be based on inference, through interpretation of measurements taken at or near the surface, through controlled laboratory experiments, and through numerical simulations. For this reason solid Earth geoscience is both a data-driven and a model-driven field. Unanticipated discoveries increasingly will come from the analysis of large data sets, novel developments in inverse theory, and procedures enabled by computationally intensive simulations. Increasingly affordable and capable sensors are dramatically increasing the data available to drive this understanding. Moreover, the increasingly realistic character of computer simulations are better able to represent the behavior of the Earth. We are faced with the challenge of gaining new insights from these data and simulations, and techniques from the rapidly evolving field of machine learning (ML) are likely to play a key role in this effort. In this talk we illustrate the promise of machine learning using recent examples from seismology.

Keywords: Seismology, Machine Learning , Earthquakes

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Automatic Approach to Low-Frequency Earthquakes Detection in Southwest Japan Based on Deep Learning Technique

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Slow earthquakes have been observed on both shallower and deeper sides of seismogenic zone of megathrust earthquakes and therefore been thought to potentially interact with disastrous megathrust ruptures. A class of slow earthquakes at a dominant frequency of 2–8 Hz, marked as deep low-frequency events (LFEs), are observed continuously along the Nankai Tough from the Southwest Shikoku to the Kii peninsula in Japan. The frequent occurrence of LFEs in this region may suggest an increased probability of impending megathrust earthquakes. Therefore, precise monitoring of the seismic activity of these LFEs may provide a key clue to the quantitative prediction of huge earthquakes and deepen our understanding of diverse earthquake processes. However, traditional approaches to earthquakes detection such as STA/LTA method fails to detect LFEs signal masked by background noise because of the lack of impulsive phase arrivals, which makes it challengeable to detect LFEs from raw seismograms automatically. The matched-filter method leverages the similarity of representative template waveform and continuous seismic waveform and has been used in the Japan Meteorological Agency (JMA) to distinguish and catalog LFEs automatically since July 2014, but it also makes detectability restricted by the limited prior knowledge that refers to available matching templates.

The recent advance in the field of deep learning has shown a robust capability of predictions or discriminations by using general features learned from fitting data, which can potentially be used in tackling LFEs detection. Deep-learning models are basically trained by scanning through large datasets and meanwhile tweaking their parameters gradually toward the direction in which the difference between fed data and the model's predictions descends.

To create training dataset in our study, we prepared a total of 4 years continuous three-component velocity seismograms data recorded by 75 stations of High-sensitivity Seismograph Network Japan (Hi-net) operated by the National Research Institute for Earth Science and Disaster Resilience (NIED) across Southwest Japan from January 2010 to December 2013. We first preprocessed raw data streams without applying bandpass filter and cut them into millions of single-station, 3-channel, 10-seconds event-waveform windows vectorized as 2D arrays at a sampling rate of 100 Hz. We then labeled 3,179,167 windows as noise, 161,930 windows as regular earthquakes, 29,090 windows as LFEs, and 262,209 windows as deep low-frequency tremors, which were considered to be a continuous LFEs signal, according to the JMA's seismic catalog and the World Tremor Database (WTD). Due to the fluctuation of the positions of seismic phases in the waveform windows, we choose to use the Convolution Neural Network (CNN); a deep-learning model that first extracts local features and then integrates them hierarchically so less disturbed by the inhomogeneity of data than the traditional model does. For each data window, the model outputs four probabilities corresponding to the likelihood of each respective class. Event detection is declared when one of four probabilities exceed the threshold we set (50% for general).

We trained the model preliminarily and evaluate the accuracy of the model on a brand-new test dataset generated by the same rules as those of creating training dataset using receiver operating characteristic

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(ROC) analysis. We were given the area under the ROC curve (AUC) score of 0.923, 0.991, 0.981, and 0.914 (naive baseline = 0.5) for noise, regular earthquake, LFEs, and deep low-frequency tremor respectively, which suggests that our model is capable of classifying waveform windows correctly with high confidence. We also noticed that there are a lot of LFEs that are incorrectly identified as tremors in spite of the low ratio of tremors that are incorrectly identified as LFEs. To find a rational explanation for this asymmetric structure and the classifying borderlines of our model, we will do more error analysis and unbox each layer of our model to visualize how they are activated in further research. And we will further tune our model and integrate the single-station classifiers to build local networks that can identify earthquake events coherently.

Keywords: slow earthquakes, LFEs, deep low-frequency tremors, earthquake detection, deep learning

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Broadband ground motion waveform synthesis utilizing AI-based upsampling technique (2)

*Takahiro Maeda[1], Asako Iwaki[1], Hiroyuki Fujiwara[1], Kazutoshi Matsuzaki[2], Hiromitsu Tomozawa[2], Yuji Mori[2], Misato Tsuchiya[2], Naofumi Miyata[2]

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To enhance the reliability of seismic hazard assessment, it is important to improve the accuracy of predicting broadband ground motion. For predicting broadband ground motion, a hybrid method is often used. The hybrid method synthesizes broadband ground motion by summing up long-period and short-period ground motion calculated separately. The long-period ground motion is calculated by a theoretical method such as the finite difference method which can consider the effect of the three-dimensional velocity structure. The short-period ground motion is calculated by empirical or semi-empirical methods such as statistical Green's function method can consider the effect of random heterogeneity of seismic source and propagation path. These methods, however, use different velocity structure models, it is known that problems such as the shift of travel time, discontinuity of spectral amplitude between the period range.

For this problem, Iwaki and Fujiwara (2013) proposed a method of synthesizing broadband ground-motion waveform based on the relationship of ground-motion waveform between long-period and short-period extracted from observation data. We considered this problem of extracting the relationship between long-period and short-period ground motions as a problem of upsampling in artificial intelligence and have studied this problem using the coupling learning method (Nagata et al., 2016) which is one of machine learning methods (Maeda et al., 2018). To construct a prediction model of a short-period ground-motion waveform from long-period ground-motion waveform based on artificial intelligence, we can utilize a vast amount of strong ground motion data recorded by K-NET and KiK-net.

The performance of the prediction model is evaluated based on the similarity of observed and predicted broadband ground motion. In the previous study, we evaluated the similarity based on the time series data of the broadband waveform. However, in this study, we used an envelope shape of waveforms for narrowband of 0.5-1.0 Hz, 1-2 Hz, 2-4 Hz, 4-8 Hz, 8-16 Hz, and a Fourier amplitude spectrum for evaluating similarity. The data sets used for learning and testing of artificial intelligence were (1) records of a single observation site, (2) records of multiple observation sites with similar ground conditions, (3) records of multiple observation sites due to earthquakes of the similar magnitude, (4) records of multiple observation sites due to earthquake occurring same region, and (5) a whole records from (1) to (4). We found a tendency that the prediction performance is somewhat higher in the case (1). Qualitatively, it is expected that the prediction performance in the case (1) that can take into consideration the site-specific characteristic of ground motion will be significantly higher and the result of this study suggests that there is room for improvement in the similarity evaluation.

Acknowledgments: This work was partially supported by the Council for Science, Technology and Innovation (CSTI) through the Cross-ministerial Strategic Innovation Promotion Program (SIP), titled “Enhancement of societal resiliency against natural disasters” (Funding agency: JST). This study was conducted as part of joint research with RIKEN.

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Keywords: broadband ground motion waveform synthesis, coupled learning method, artificial intelligence

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Forecast trial of postseismic deformetion after the 2011 Tohoku-Oki earthquake by recurrent neural network

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The 2011 Tohoku-Oki earthquake caused large postseismic deformation, hiding possible small signals, such as slow slips and volcanic events. In general, postseismic deformation is fitted by a logarithmic, exponential or their combined function. To forecast postseismic deformation more accurately, we introduce a recurrent neural network method which is one of the machine learning approaches. This method autonomously learns relation between input and output data. We use 700-days sequence of GNSS time-series data of 191 stations (GEONET) as input data and the following data as output data for training the neural network. The results of the neural network better forecast the time-series data than those of regression analyses in an E-W direction. However, in an N-S direction, the neural network does not work better than regression analyses. These facts indicate that data with a sufficiently small signal to noise ratio is needed for the neural network. In the results of the E-W direction, we find several regions with low precision of the forecast, partly corresponding to the Niigata-Kobe strain concentration zone, as well as along the coast of Sea of Japan in northern Tohoku.

Keywords: neural network, postseismic deformation

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Deep Learning Approaches for Eruption Prediction of Sakurajima

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In this research, we take advantages of deep learning into time series data and apply this technique to sensor data acquired from volcanic monitors.
We focus on two problems: (1) volcanic eruption classification and (2) early prediction of volcanic eruption. The goal of (1) is to recognize the current status of the volcano, while the goal of (2) is to predict the future eruption by detecting the time series prior to the eruption which is the early signal of the upcoming eruption. For (1), the proposed method VolNet based on convolutional neural network achieves an average F-score of 90%. For (2), the proposed method based on Stacked 2-Layer LSTM achieves promising results of 66.1% accuracy. And the accuracy of 4-stage warning system is 51% in the critical stage. We demonstrate the effectiveness of our methods with the largest and the most comprehensive set of volcano sensor time series data.

Keywords: Eruption Prediction, Sakurajima, Deep Learning

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[J] Poster | S (Solid Earth Sciences)：S-CG Complex & General

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_21

[S-CG62] Potentiality of Machine Learning in Solid Earth Sciences

convener:Takahiko Uchide(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST)

The recent development of the machine learning techniques including the deep learning is leading innovations in various fields. The applications of these techniques to solid earth sciences are also expected to develop new frontiers by, for example, the classification, the pattern recognition, and the regression of data. On the other hand, there are concerns on the human-interpretability of the deep learning.
This session will provide an opportunity to share the application studies to various fields in solid earth science and inspire each other. We also look forward to studies addressing the black box issue of the deep learning.

[SCG62-P01] Earthquake Magnitude Prediction with Seismic Nucleation Phase based on Machine Learning

*Kangming Wu[1], Hiroe Miyake[2] (1.GSII, The University of Tokyo, 2.III, The University of Tokyo)

[SCG62-P02] Automatic signal classification for continuous seismic waveform records based on an unsupervised learning algorithm: Application to artificial noises and low-frequency tremors

*Yuki Kodera[1], Shin'ichi Sakai[2], Takahito Nishimiya[1] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.Earthquake Research Institute, the University of Tokyo)

[SCG62-P03] Detection of Gas Bubble signals recorded at the OBS Stations by Machine-Learning

*emmy TY CHANG[1] (1.Institute of Oceanography, National Taiwan University)

[SCG62-P04] Automatic Phase Picking of Seismograms by Deep Neural Network

*Takahiko Uchide[1] (1.Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST))

[SCG62-P05] **Seismic event detection in time-frequency domain with CNN and phase picking with HED**

*Liping Fan[1] (1.Institute of Geophysics, China Earthquake Administration)

[SCG62-P06] Broadband ground-motion synthesis using embeddig machine learning

*Tomohisa Okazaki[1], Hirotaka Hachiya[1], Naonori Ueda[1], Asako Iwaki[2], Takahiro Maeda[2], Hiroyuki Fujiwara[2] (1.Center for Advanced Intelligence Project, RIKEN, 2.National Research Institute for Earth Science and Disaster Resilience)

[SCG62-P07] LSTM and CNN Applications to Forecast Earthquake Magnitude Probability Distribution

*Qi Liu[1], Hiroe Miyake[2], Hiroshi Tsuruoka[3] (1.GSII, The University of Tokyo, 2.III, The University of Tokyo, 3.ERI, The University of Tokyo)

[SCG62-P08] *FORCsensei*: A machine learning framework to estimate optimized first-order reversal curve distributions

David Heslop[1,2], Andrew Roberts[1,2], *Hirokuni Oda[2], Xiang Zhao[1,2], Richard Harrison[3], Adrian Muxworthy[4], Pengxiang Hu[1,2], Tetsuro Sato[2] (1.Australian National University, 2.Institute of Geology and Geoinformation, Geological Survey of Japan, AIST, 3.University of Cambridge, 4.Imperial College London)

Earthquake Magnitude Prediction with Seismic Nucleation Phase based on Machine Learning

*Kangming Wu[1], Hiroe Miyake[2]

1. GSII, The University of Tokyo, 2. III, The University of Tokyo

Understanding the mechanism of earthquake generation and predicting magnitude is an important research direction in seismology. In seismology, there are typical two models to explain how rupture grows and becomes an earthquake: nucleation model and cascade model. The nucleation model considers earthquakes start from weak faults pre-slip, then grow up. According to the hypothesis, the duration of seismic nucleation phase is proportional to the eventual size of the earthquake. We try to verify it with machine learning approaches and try to implement it on real magnitude predictions.

Machine learning, especially deep learning, has been proved that they can solve many problems that traditional algorithm cannot or hard to solve, but require higher computational power to train models to learn patterns in dataset. Hardware performance improvement in recent years energizes it and boom at about 2010. Machine learning have many applications like Autopilot, NPL (Natural Language Processing), stock market prediction, but seismic researches based on machine learning are few. Implement machine learning in seismology may bring some progresses in researches and applications.

In this research, we used the NIED Hi-net data, the JMA unified hypocenter catalogs, and the NIED seismic stations information to create the dataset of the model to detect seismic nucleation phase. Wave segments of seismic nucleation phase will become input, earthquake magnitudes will become output. Fourier transform is planned to be used for filter noise in wave. We are planning to use seismic wave data collected from Hi-net since 2004, but lack of high magnitude earthquakes might be a problem to build the dataset, which makes the trained model have bad performance in high magnitude earthquakes. Some Deep Learning models like MLP (multilayer perceptron), RNN (Recurrent Neural Network) and traditional Machine Learning models will be implemented to compare their performance. We have not decided to treat it as a regression problem, a classification problem or both. Magnitude or amount of energy release from earthquakes can be used as labels in a regression algorithm, while rounding magnitude can be used as labels in a classification problem. Some indicators of model performance like Mean Square Error and Confusion Matrix are used to evaluate and improve the model.

Keywords: machine learning, seismic nucleation phase

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Automatic signal classification for continuous seismic waveform records based on an unsupervised learning algorithm: Application to artificial noises and low-frequency tremors

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Continuous seismic records catch various signals such as earthquakes, human activities, and instrumental noises. Extracting and analyzing these signals are important for earthquake early warning (EEW) operations. Using earthquake signals, we can evaluate the detection capability of the seismometer and calibrate the site amplification factor. Artificial noise signals tell us about the current data quality of the seismometer and the possibility of false alarm issuance. In addition to the EEW purpose, classifying natural and non-natural signals may contribute to the better understanding of geophysical phenomena around the observation network. In this study, we have developed an automatic classification algorithm for continuous records based on a machine learning method.

An unsupervised learning algorithm is employed in our approach because observed signals in continuous records vary depending on every seismometer. We assume that we do not have the knowledge of the recorded signals in advance and that labeled training data are not available that can be used for a supervised learning. The method is based on clustering in the frequency and time domains. First, features are obtained by computing running spectra with a 4-s time window and 0.1-s interval, applying a triangular filter bank with 10 bands. After that, the features are clustered in the 10-dimensional feature space using the k-means algorithm. Then, the spectral clustering algorithm is performed with the assumption of the transition matrix of a Markov chain. Ten time-series models are finally obtained and used for the classification.

We applied the method to continuous waveforms recorded at (1) Station E.JDJM, which is a seismometer of the Metropolitan Seismic Observation network (MeSO-net) located close to the subway and (2) a temporary ocean-bottom seismometer (OBS) to observe aftershocks of the 2004 M7.4 off the Kii Peninsula Earthquake (Yamazaki et al., 2008). For the record of Station E.JDJM, the algorithm discriminated earthquake signals and train noises from background noises. For the OBS record, low-frequency tremors with large amplitudes were automatically detected in addition to regular earthquakes. The method successfully classified continuous records of the MeSO-net station and OBS although those seismometers had unique observation environments and diverse recorded signals. This indicates the potential for the wide applicability of the unsupervised learning approach and the contribution of monitoring seismometer conditions and geophysical phenomena.

Keywords: Machine learning, Earthquake early warning, Low-frequency tremor, Automatic classification, MeSO-net, Ocean-bottom seismometer

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Detection of Gas Bubble signals recorded at the OBS Stations by Machine-Learning

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Along the OBS seismograms, the waveforms of gas emission signals exhibit a high-frequency resonant vibration alike the bubble bursting at the free surface of a non-Newtonian fluid. Every single signal is a short-duration event (hereafter termed as “SDE”, <1.0 second). In this study, we shall develop the computer algorithm to detect the SDE signals along the OBS seismograms. Our work carried out in 2018 has been laid on the mathematical matching of the bubble signals. We conclude that even though the bubbles exhibit a specific waveform, the mathematical equation cannot perfectly describe the bubble with all ambient conditions at the seafloor. Our strategy is to adopt the Machine Learning (ML) to identify bubbles by images. In the following years, two phases of our project are designed as (i) Establishing the method to quantify the SDE signals by means of ML modeling: we shall train a neural network model with varied parameters to gain a complete estimation of the bubble signals within our OBS records. (ii) The experiments with OBS instruments will also be used for tests of generating different waveforms in water tanks of the ifremer as well as a constrained offshore area (e.g. lake), to provide referenced waveforms for the SDE or bubble signals.

Keywords: gas emission, bubble, machine learning, Ocean bottom seismometer

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Automatic Phase Picking of Seismograms by Deep Neural Network

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The identification of arrival times of P and S waves is often the first step of seismic data analyses. Cross-correlation-based methods, such as the matched filter method, are often used for identifying events and measuring relative arrival times. Those methods require template events and otherwise significant computational cost for taking cross-correlation of much seismic data. Especially in the case of campaign observations, the preparation of template events requires manual picking of many events, which is tough process.

I built an automatic phase picking system by a deep neural network with an inception module. I use seismograms from Hi-net for earthquakes in the northern Ibaraki prefecture and the Fukushima Hamadori areas, where the seismicity rate is high since the 2011 Tohoku-oki earthquake. The P and S arrivals are the manually picked ones in the JMA Unified Earthquake Catalog. I introduce the picking data as one-hot vectors.

The trained neural network gives P arrivals within 0.02 s from the JMA data for more than 70 % of seismograms. We empirically relate the output to the probability, which will give the accuracy of the arrival times given by the neural network.

Acknowledgement

We used the seismic data from Hi-net of NIED and the phase data from JMA. We also used the PyTorch library, and ABCI and AAIC supercomputers of AIST. This work is supported by Research Grants in the Natural Sciences by the Mitsubishi Foundation and AIST EDGE Runners project.

Keywords: Earthquakes, Automatic Phase Picking, Deep Learning

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Seismic event detection in time-frequency domain with CNN and phase picking with HED

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The P-wave and S-wave arrivals are critical data in seismic research. The quantity, accuracy and consistency of these greatly affect the final result of imaging of faults, earthquake early warning, and the inversion of Earth structure. Generally, earthquake phases are picked manually by analysts. On the one hand, poor data consistency maybe exists resulting from changes of analysts; on the other hand, the amount of seismic data increases exponentially, and it overwhelms analysts. It is urgent to develop an efficient and stable method of event detection and phase picking.

Traditional automatic event detection and phase picking methods are mainly divided into two categories: 1) Methods based on waveform characteristics such as amplitude, frequency and waveform envelope, which are the STA/LTA method, the regression method, the high-order statistics method, the main cycle method, the envelope function method, and the neural network method; 2) Various waveform correlation methods proposed according to waveform similarity, such as the waveform autocorrelation technique, the template matching technique, and the fingerprint and similarity threshold (FAST) method. Although these methods have achieved great success, they still have inherent disadvantages. For example, it’ s hard to set the threshold relative to varied noise level in the LTA/STA method; detected earthquakes in the template matching method are restricted to locations of the template earthquake position. Methods extracting waveform features automatically independent of the noise level and waveform similarity meet our requirements.

Deep Neural Network (DNN) is a breakthrough in feature learning methods in recent years. It has excellent automatic feature learning ability and the model is able to represent the essential characteristics of the data. Perol et al. trained a convolutional neural network for earthquake detection (ConvNetQuake), which gives a higher efficiency and precision than previous traditional methods. Ross et al. gave a convolutional neural network to detect seismic body-wave phases. Dokht et al. divided the automatic earthquake phases detection process into two steps: a pretrained model detecting earthquakes from continuous waveforms in the time-frequency domain and a supervised classification system discriminating between P and S waves. The first-part model enhanced the detection accuracy compared with ConvNetQuake. Inspired by the work of Dokht et al. and the latest progress in edge detection algorithms (the holistically-nested edge detection method), we propose a two-step phase picking framework. It is a former convolutional neural network for earthquake detection and a later network based on holistically-nested edge detection method (HED) for phase picking.

The data set used for training earthquake-detection model is 7,719 earthquake waveforms recorded by Xichang seismic array in Sichuan province of China during January 2013 to December 2016. The local magnitudes M_L range from -1.1 to 5.8. The number of noise records is 7,000. The time window length is 40 seconds. These earthquake waveforms are preprocessed by the following steps: removing instrument response, high-pass filtering above 1Hz, manually checking and removing low quality data, short-time Fourier transforming and normalization. The network contains 4 convolutional layers, 4 max pooling layers and 2 fully connected layers. The amount of P-wave arrival is 40,464 and that of S-wave arrive is 39,967. Ground truths of those 10-seconds-length windows are used for training network for phase picking. This

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network structure is built based on VGG16.

Providing continuous waveforms to seismic event detection model as input, it gives the start time of detected event windows. Feed these detected windows to the phase picking model and it export time of phase arrivals. Our models detect more seismic events and pick more accurate arrival time in comparison with previous models.

Keywords: event detection, phase picking, convolutional neural network, holistically-nested edge detection method

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Broadband ground-motion synthesis using embeddig machine learning

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Broadband ground-motion predictions are performed to estimate seismic hazards. A standard hybrid approach combines long-period motions calculated by a numerical simulation and short-period motions by a statistical method to synthesize broancband motions. But it still has drawbacks that generated short period motions do not reflect source and path effects, and resulting building responses can be inconsistent over the joint periods between the long and short periods.

In recent years, another approach has been proposed which models the relation between long and short period, and estimates short-period waves from long-period ones (Iwaki et al., 2016; Paolucci et al., 2018). Iwaki et al. (2016) modeled the relations of envelope waves in different bands using earthquakes similar to a target earthquake. We attempt to model this relation using a machine learning method.

The envelope waves are estimated using embedding. A common embedded space representing both long and short period motions is built by an extended version of t-SNE (van der Maaten and Hinton, 2008), so that neighbor identities of envelopes are preserved. Then, unknown broadband envelopes for test data can be interpolated in this space. The similarity of envelopes is measured by the Wasserstein distance of the optimal transport theory.

Then, the frequency property is estimated using neural networks. The Fourier spectrum of the short period motion are estimated from that of the long period motion. We first train the network with large data from all sites to model a general frequency property, and then retrain it with small data from a specific site to model a site-specific frequency property. We found that this approach could avoid overfitting and improve the accuracy. Finally, the estimated time and frequency properties are combined to synthesize broadband ground motions using random phases.

We investigated an M7.0 Ibaraki-oki earthquake in 2008, and showed that the resulting broadband ground motions could match the ground-truth observations well both in envelope shapes and building responses.

Keywords: ground motion prediction, embedding

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LSTM and CNN Applications to Forecast Earthquake Magnitude Probability Distribution

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An earthquake is one of the most dangerous natural disasters. And for us, earthquake is not only resulted in economic loss, but also the physiological and psychological trauma. There are two main ways to avert these kinds of loss: One is earthquake early warning, the other is earthquake prediction. Compare to the earthquake early warning, the earthquake prediction seems to be more useful for disaster mitigation, decrease damage by earthquakes, but unfortunately it is more difficult to predict with accurate physics-based ways, even sometimes is thought to be impossible. Spatial distribution of earthquakes has some relationships with the structure of the Earth. Temporal distribution of earthquakes has some relationships with mechanical properties and stress state of the Earth. There are a lot of studies that count earthquake events for finding several laws of earthquakes with great achievements: Omori formula, Modified Omori formula, ETAS model, and etc. These traditional models had good performance on the aftershock forecasting, but are not good enough to the mainshock forecasting. The earthquake occurrence is generally according to the Poisson distribution which follows the power law. This kind of distribution is meaningful because the earthquake event has same probability of occurrence per unit time. This is one of reasons why it is difficult to forecast mainshocks.

With the development of computer science, several new technologies have been created: liner regression, nonlinear regression, and classification based on machine learning. According to updates of computer hardware, not only original machine learning such as Random Forest (RF), Support Vector Machines (SVM), and Neural Network (NN) has been used for the earthquake data mining but also several Neural Network deep learning methods has been abundantly used for these forecasting problems. Nowadays imagine identification technology based on Convolutional Neural Network (CNN) and text generation technology based on Recurrent Neural Network (RNN) are the most representative technologies. These two kinds of most useful Neural Network models are also widely used for spatial data mining as well as temporal data mining. We consider to combine these two Neural Networks to find spatio-temporal relationship among earthquakes at different positions and to perform earthquake event forecasting by taking advantage of this relationship.

At 14:46 on 11 March 2011, the Tohoku earthquake occurred. It is well-known that predicting this kind of a giant earthquake is most helpful to us for disaster mitigation. In this study, we use earthquake event data within 100 km depth in 2000-2010 from the JMA (Japan Meteorological Agency) unified catalog, and sort out one-day JMA magnitude probability distribution values (events number, magnitude average value, maximum magnitude value, and standard value) as one dataset per spatial grid to cover the catalog over Japan. Through supervised learning, we forecast earthquake magnitude probability distribution based on LSTM RNN (Long-Short Term Memory Recurrent Neural Network) and CNN (Convolutional Neural Network) prior to the 2011 Tohoku earthquake.

Keywords: machine learning , earthquake forecasting, Recurrent Neural Network

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FORCsensei: A machine learning framework to estimate optimized first-order reversal curve distributions

David Heslop[1,2], Andrew Roberts[1,2], *Hirokuni Oda[2], Xiang Zhao[1,2], Richard Harrison[3], Adrian Muxworthy[4], Pengxiang Hu[1,2], Tetsuro Sato[2]

1. Australian National University, 2. Institute of Geology and Geoinformation, Geological Survey of Japan, AIST, 3. University of Cambridge, 4. Imperial College London

First-order reversal curve (FORC) distributions are a powerful diagnostic tool for characterizing and quantifying magnetization processes in fine magnetic particle systems. Estimation of FORC distributions requires computation of the second-order mixed derivative of noisy magnetic hysteresis data. This operation amplifies measurement noise and for weakly magnetic systems it can compromise estimation of a FORC distribution. Several processing schemes, typically based on local polynomial regression, have been developed to produce smoothed FORC distributions that suppress detrimental noise. As FORC analysis has become more quantitative, the smoothed distribution needs to be consistent with the measurement data from which it was estimated. This can be a challenging task even for expert users, who must subjectively adjust parameters that define the form and extent of smoothing until a satisfactory FORC distribution is obtained. For non-expert users, estimation of FORC distributions using inappropriate smoothing parameters can produce heavily distorted results corrupted by processing artifacts, which in turn can lead to spurious inferences concerning the magnetic system under investigation. We have developed a statistical machine learning framework based on probabilistic model comparison to guide estimation of FORC distributions. An intuitive approach is presented that reveals which regions of a FORC distribution may have been smoothed inappropriately. Our machine learning approach will objectively select an optimal FORC distribution probabilistically, which will automate the derivative estimation process for both expert and non-expert users.

Keywords: machine learning, First Order Reversal Curve, magnetic hysteresis, mixed second derivative

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[J] Poster | S (Solid Earth Sciences)：S-CG Complex & General

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_35

[S-CG62] Potentiality of Machine Learning in Solid Earth Sciences

convener:Takahiko Uchide(Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)), Hirokuni Oda(Institute of Geology and Geoinformation, Geological Survey of Japan, AIST)

The recent development of the machine learning techniques including the deep learning is leading innovations in various fields. The applications of these techniques to solid earth sciences are also expected to develop new frontiers by, for example, the classification, the pattern recognition, and the regression of data. On the other hand, there are concerns on the human-interpretability of the deep learning.
This session will provide an opportunity to share the application studies to various fields in solid earth science and inspire each other. We also look forward to studies addressing the black box issue of the deep learning.

[SCG62-P01] Earthquake Magnitude Prediction with Seismic Nucleation Phase based on Machine Learning

*Kangming Wu[1], Hiroe Miyake[2] (1.GSII, The University of Tokyo, 2.III, The University of Tokyo)

[SCG62-P02] Automatic signal classification for continuous seismic waveform records based on an unsupervised learning algorithm: Application to artificial noises and low-frequency tremors

*Yuki Kodera[1], Shin'ichi Sakai[2], Takahito Nishimiya[1] (1.Meteorological Research Institute, Japan Meteorological Agency, 2.Earthquake Research Institute, the University of Tokyo)

[SCG62-P03] Detection of Gas Bubble signals recorded at the OBS Stations by Machine-Learning

*emmy TY CHANG[1] (1.Institute of Oceanography, National Taiwan University)

[SCG62-P04] Automatic Phase Picking of Seismograms by Deep Neural Network

*Takahiko Uchide[1] (1.Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST))

[SCG62-P05] **Seismic event detection in time-frequency domain with CNN and phase picking with HED**

*Liping Fan[1] (1.Institute of Geophysics, China Earthquake Administration)

[SCG62-P06] Broadband ground-motion synthesis using embeddig machine learning

*Tomohisa Okazaki[1], Hirotaka Hachiya[1], Naonori Ueda[1], Asako Iwaki[2], Takahiro Maeda[2], Hiroyuki Fujiwara[2] (1.Center for Advanced Intelligence Project, RIKEN, 2.National Research Institute for Earth Science and Disaster Resilience)

[SCG62-P07] LSTM and CNN Applications to Forecast Earthquake Magnitude Probability Distribution

*Qi Liu[1], Hiroe Miyake[2], Hiroshi Tsuruoka[3] (1.GSII, The University of Tokyo, 2.III, The University of Tokyo, 3.ERI, The University of Tokyo)

[SCG62-P08] *FORCsensei*: A machine learning framework to estimate optimized first-order reversal curve distributions

David Heslop[1,2], Andrew Roberts[1,2], *Hirokuni Oda[2], Xiang Zhao[1,2], Richard Harrison[3], Adrian Muxworthy[4], Pengxiang Hu[1,2], Tetsuro Sato[2] (1.Australian National University, 2.Institute of Geology and Geoinformation, Geological Survey of Japan, AIST, 3.University of Cambridge, 4.Imperial College London)

Earthquake Magnitude Prediction with Seismic Nucleation Phase based on Machine Learning

*Kangming Wu[1], Hiroe Miyake[2]

1. GSII, The University of Tokyo, 2. III, The University of Tokyo

Understanding the mechanism of earthquake generation and predicting magnitude is an important research direction in seismology. In seismology, there are typical two models to explain how rupture grows and becomes an earthquake: nucleation model and cascade model. The nucleation model considers earthquakes start from weak faults pre-slip, then grow up. According to the hypothesis, the duration of seismic nucleation phase is proportional to the eventual size of the earthquake. We try to verify it with machine learning approaches and try to implement it on real magnitude predictions.

Machine learning, especially deep learning, has been proved that they can solve many problems that traditional algorithm cannot or hard to solve, but require higher computational power to train models to learn patterns in dataset. Hardware performance improvement in recent years energizes it and boom at about 2010. Machine learning have many applications like Autopilot, NPL (Natural Language Processing), stock market prediction, but seismic researches based on machine learning are few. Implement machine learning in seismology may bring some progresses in researches and applications.

In this research, we used the NIED Hi-net data, the JMA unified hypocenter catalogs, and the NIED seismic stations information to create the dataset of the model to detect seismic nucleation phase. Wave segments of seismic nucleation phase will become input, earthquake magnitudes will become output. Fourier transform is planned to be used for filter noise in wave. We are planning to use seismic wave data collected from Hi-net since 2004, but lack of high magnitude earthquakes might be a problem to build the dataset, which makes the trained model have bad performance in high magnitude earthquakes. Some Deep Learning models like MLP (multilayer perceptron), RNN (Recurrent Neural Network) and traditional Machine Learning models will be implemented to compare their performance. We have not decided to treat it as a regression problem, a classification problem or both. Magnitude or amount of energy release from earthquakes can be used as labels in a regression algorithm, while rounding magnitude can be used as labels in a classification problem. Some indicators of model performance like Mean Square Error and Confusion Matrix are used to evaluate and improve the model.

Keywords: machine learning, seismic nucleation phase

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Automatic signal classification for continuous seismic waveform records based on an unsupervised learning algorithm: Application to artificial noises and low-frequency tremors

*Yuki Kodera[1], Shin'ichi Sakai[2], Takahito Nishimiya[1]

1. Meteorological Research Institute, Japan Meteorological Agency, 2. Earthquake Research Institute, the University of Tokyo

Continuous seismic records catch various signals such as earthquakes, human activities, and instrumental noises. Extracting and analyzing these signals are important for earthquake early warning (EEW) operations. Using earthquake signals, we can evaluate the detection capability of the seismometer and calibrate the site amplification factor. Artificial noise signals tell us about the current data quality of the seismometer and the possibility of false alarm issuance. In addition to the EEW purpose, classifying natural and non-natural signals may contribute to the better understanding of geophysical phenomena around the observation network. In this study, we have developed an automatic classification algorithm for continuous records based on a machine learning method.

An unsupervised learning algorithm is employed in our approach because observed signals in continuous records vary depending on every seismometer. We assume that we do not have the knowledge of the recorded signals in advance and that labeled training data are not available that can be used for a supervised learning. The method is based on clustering in the frequency and time domains. First, features are obtained by computing running spectra with a 4-s time window and 0.1-s interval, applying a triangular filter bank with 10 bands. After that, the features are clustered in the 10-dimensional feature space using the k-means algorithm. Then, the spectral clustering algorithm is performed with the assumption of the transition matrix of a Markov chain. Ten time-series models are finally obtained and used for the classification.

We applied the method to continuous waveforms recorded at (1) Station E.JDJM, which is a seismometer of the Metropolitan Seismic Observation network (MeSO-net) located close to the subway and (2) a temporary ocean-bottom seismometer (OBS) to observe aftershocks of the 2004 M7.4 off the Kii Peninsula Earthquake (Yamazaki et al., 2008). For the record of Station E.JDJM, the algorithm discriminated earthquake signals and train noises from background noises. For the OBS record, low-frequency tremors with large amplitudes were automatically detected in addition to regular earthquakes. The method successfully classified continuous records of the MeSO-net station and OBS although those seismometers had unique observation environments and diverse recorded signals. This indicates the potential for the wide applicability of the unsupervised learning approach and the contribution of monitoring seismometer conditions and geophysical phenomena.

Keywords: Machine learning, Earthquake early warning, Low-frequency tremor, Automatic classification, MeSO-net, Ocean-bottom seismometer

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Detection of Gas Bubble signals recorded at the OBS Stations by Machine-Learning

*emmy TY CHANG[1]

1. Institute of Oceanography, National Taiwan University

Along the OBS seismograms, the waveforms of gas emission signals exhibit a high-frequency resonant vibration alike the bubble bursting at the free surface of a non-Newtonian fluid. Every single signal is a short-duration event (hereafter termed as “SDE”, <1.0 second). In this study, we shall develop the computer algorithm to detect the SDE signals along the OBS seismograms. Our work carried out in 2018 has been laid on the mathematical matching of the bubble signals. We conclude that even though the bubbles exhibit a specific waveform, the mathematical equation cannot perfectly describe the bubble with all ambient conditions at the seafloor. Our strategy is to adopt the Machine Learning (ML) to identify bubbles by images. In the following years, two phases of our project are designed as (i) Establishing the method to quantify the SDE signals by means of ML modeling: we shall train a neural network model with varied parameters to gain a complete estimation of the bubble signals within our OBS records. (ii) The experiments with OBS instruments will also be used for tests of generating different waveforms in water tanks of the ifremer as well as a constrained offshore area (e.g. lake), to provide referenced waveforms for the SDE or bubble signals.

Keywords: gas emission, bubble, machine learning, Ocean bottom seismometer

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Automatic Phase Picking of Seismograms by Deep Neural Network

*Takahiko Uchide[1]

1. Research Institute of Earthquake and Volcano Geology, Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology (AIST)

The identification of arrival times of P and S waves is often the first step of seismic data analyses. Cross-correlation-based methods, such as the matched filter method, are often used for identifying events and measuring relative arrival times. Those methods require template events and otherwise significant computational cost for taking cross-correlation of much seismic data. Especially in the case of campaign observations, the preparation of template events requires manual picking of many events, which is tough process.

I built an automatic phase picking system by a deep neural network with an inception module. I use seismograms from Hi-net for earthquakes in the northern Ibaraki prefecture and the Fukushima Hamadori areas, where the seismicity rate is high since the 2011 Tohoku-oki earthquake. The P and S arrivals are the manually picked ones in the JMA Unified Earthquake Catalog. I introduce the picking data as one-hot vectors.

The trained neural network gives P arrivals within 0.02 s from the JMA data for more than 70 % of seismograms. We empirically relate the output to the probability, which will give the accuracy of the arrival times given by the neural network.

Acknowledgement

We used the seismic data from Hi-net of NIED and the phase data from JMA. We also used the PyTorch library, and ABCI and AAIC supercomputers of AIST. This work is supported by Research Grants in the Natural Sciences by the Mitsubishi Foundation and AIST EDGE Runners project.

Keywords: Earthquakes, Automatic Phase Picking, Deep Learning

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Seismic event detection in time-frequency domain with CNN and phase picking with HED

*Liping Fan[1]

1. Institute of Geophysics, China Earthquake Administration

The P-wave and S-wave arrivals are critical data in seismic research. The quantity, accuracy and consistency of these greatly affect the final result of imaging of faults, earthquake early warning, and the inversion of Earth structure. Generally, earthquake phases are picked manually by analysts. On the one hand, poor data consistency maybe exists resulting from changes of analysts; on the other hand, the amount of seismic data increases exponentially, and it overwhelms analysts. It is urgent to develop an efficient and stable method of event detection and phase picking.

Traditional automatic event detection and phase picking methods are mainly divided into two categories: 1) Methods based on waveform characteristics such as amplitude, frequency and waveform envelope, which are the STA/LTA method, the regression method, the high-order statistics method, the main cycle method, the envelope function method, and the neural network method; 2) Various waveform correlation methods proposed according to waveform similarity, such as the waveform autocorrelation technique, the template matching technique, and the fingerprint and similarity threshold (FAST) method. Although these methods have achieved great success, they still have inherent disadvantages. For example, it’ s hard to set the threshold relative to varied noise level in the LTA/STA method; detected earthquakes in the template matching method are restricted to locations of the template earthquake position. Methods extracting waveform features automatically independent of the noise level and waveform similarity meet our requirements.

Deep Neural Network (DNN) is a breakthrough in feature learning methods in recent years. It has excellent automatic feature learning ability and the model is able to represent the essential characteristics of the data. Perol et al. trained a convolutional neural network for earthquake detection (ConvNetQuake), which gives a higher efficiency and precision than previous traditional methods. Ross et al. gave a convolutional neural network to detect seismic body-wave phases. Dokht et al. divided the automatic earthquake phases detection process into two steps: a pretrained model detecting earthquakes from continuous waveforms in the time-frequency domain and a supervised classification system discriminating between P and S waves. The first-part model enhanced the detection accuracy compared with ConvNetQuake. Inspired by the work of Dokht et al. and the latest progress in edge detection algorithms (the holistically-nested edge detection method), we propose a two-step phase picking framework. It is a former convolutional neural network for earthquake detection and a later network based on holistically-nested edge detection method (HED) for phase picking.

The data set used for training earthquake-detection model is 7,719 earthquake waveforms recorded by Xichang seismic array in Sichuan province of China during January 2013 to December 2016. The local magnitudes M_L range from -1.1 to 5.8. The number of noise records is 7,000. The time window length is 40 seconds. These earthquake waveforms are preprocessed by the following steps: removing instrument response, high-pass filtering above 1Hz, manually checking and removing low quality data, short-time Fourier transforming and normalization. The network contains 4 convolutional layers, 4 max pooling layers and 2 fully connected layers. The amount of P-wave arrival is 40,464 and that of S-wave arrive is 39,967. Ground truths of those 10-seconds-length windows are used for training network for phase picking. This

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network structure is built based on VGG16.

Providing continuous waveforms to seismic event detection model as input, it gives the start time of detected event windows. Feed these detected windows to the phase picking model and it export time of phase arrivals. Our models detect more seismic events and pick more accurate arrival time in comparison with previous models.

Keywords: event detection, phase picking, convolutional neural network, holistically-nested edge detection method

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Broadband ground-motion synthesis using embeddig machine learning

*Tomohisa Okazaki[1], Hirotaka Hachiya[1], Naonori Ueda[1], Asako Iwaki[2], Takahiro Maeda[2], Hiroyuki Fujiwara[2]

1. Center for Advanced Intelligence Project, RIKEN, 2. National Research Institute for Earth Science and Disaster Resilience

Broadband ground-motion predictions are performed to estimate seismic hazards. A standard hybrid approach combines long-period motions calculated by a numerical simulation and short-period motions by a statistical method to synthesize broancband motions. But it still has drawbacks that generated short period motions do not reflect source and path effects, and resulting building responses can be inconsistent over the joint periods between the long and short periods.

In recent years, another approach has been proposed which models the relation between long and short period, and estimates short-period waves from long-period ones (Iwaki et al., 2016; Paolucci et al., 2018). Iwaki et al. (2016) modeled the relations of envelope waves in different bands using earthquakes similar to a target earthquake. We attempt to model this relation using a machine learning method.

The envelope waves are estimated using embedding. A common embedded space representing both long and short period motions is built by an extended version of t-SNE (van der Maaten and Hinton, 2008), so that neighbor identities of envelopes are preserved. Then, unknown broadband envelopes for test data can be interpolated in this space. The similarity of envelopes is measured by the Wasserstein distance of the optimal transport theory.

Then, the frequency property is estimated using neural networks. The Fourier spectrum of the short period motion are estimated from that of the long period motion. We first train the network with large data from all sites to model a general frequency property, and then retrain it with small data from a specific site to model a site-specific frequency property. We found that this approach could avoid overfitting and improve the accuracy. Finally, the estimated time and frequency properties are combined to synthesize broadband ground motions using random phases.

We investigated an M7.0 Ibaraki-oki earthquake in 2008, and showed that the resulting broadband ground motions could match the ground-truth observations well both in envelope shapes and building responses.

Keywords: ground motion prediction, embedding

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LSTM and CNN Applications to Forecast Earthquake Magnitude Probability Distribution

*Qi Liu[1], Hiroe Miyake[2], Hiroshi Tsuruoka[3]

1. GSII, The University of Tokyo, 2. III, The University of Tokyo, 3. ERI, The University of Tokyo

An earthquake is one of the most dangerous natural disasters. And for us, earthquake is not only resulted in economic loss, but also the physiological and psychological trauma. There are two main ways to avert these kinds of loss: One is earthquake early warning, the other is earthquake prediction. Compare to the earthquake early warning, the earthquake prediction seems to be more useful for disaster mitigation, decrease damage by earthquakes, but unfortunately it is more difficult to predict with accurate physics-based ways, even sometimes is thought to be impossible. Spatial distribution of earthquakes has some relationships with the structure of the Earth. Temporal distribution of earthquakes has some relationships with mechanical properties and stress state of the Earth. There are a lot of studies that count earthquake events for finding several laws of earthquakes with great achievements: Omori formula, Modified Omori formula, ETAS model, and etc. These traditional models had good performance on the aftershock forecasting, but are not good enough to the mainshock forecasting. The earthquake occurrence is generally according to the Poisson distribution which follows the power law. This kind of distribution is meaningful because the earthquake event has same probability of occurrence per unit time. This is one of reasons why it is difficult to forecast mainshocks.

With the development of computer science, several new technologies have been created: liner regression, nonlinear regression, and classification based on machine learning. According to updates of computer hardware, not only original machine learning such as Random Forest (RF), Support Vector Machines (SVM), and Neural Network (NN) has been used for the earthquake data mining but also several Neural Network deep learning methods has been abundantly used for these forecasting problems. Nowadays imagine identification technology based on Convolutional Neural Network (CNN) and text generation technology based on Recurrent Neural Network (RNN) are the most representative technologies. These two kinds of most useful Neural Network models are also widely used for spatial data mining as well as temporal data mining. We consider to combine these two Neural Networks to find spatio-temporal relationship among earthquakes at different positions and to perform earthquake event forecasting by taking advantage of this relationship.

At 14:46 on 11 March 2011, the Tohoku earthquake occurred. It is well-known that predicting this kind of a giant earthquake is most helpful to us for disaster mitigation. In this study, we use earthquake event data within 100 km depth in 2000-2010 from the JMA (Japan Meteorological Agency) unified catalog, and sort out one-day JMA magnitude probability distribution values (events number, magnitude average value, maximum magnitude value, and standard value) as one dataset per spatial grid to cover the catalog over Japan. Through supervised learning, we forecast earthquake magnitude probability distribution based on LSTM RNN (Long-Short Term Memory Recurrent Neural Network) and CNN (Convolutional Neural Network) prior to the 2011 Tohoku earthquake.

Keywords: machine learning , earthquake forecasting, Recurrent Neural Network

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FORCsensei: A machine learning framework to estimate optimized first-order reversal curve distributions

David Heslop[1,2], Andrew Roberts[1,2], *Hirokuni Oda[2], Xiang Zhao[1,2], Richard Harrison[3], Adrian Muxworthy[4], Pengxiang Hu[1,2], Tetsuro Sato[2]

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First-order reversal curve (FORC) distributions are a powerful diagnostic tool for characterizing and quantifying magnetization processes in fine magnetic particle systems. Estimation of FORC distributions requires computation of the second-order mixed derivative of noisy magnetic hysteresis data. This operation amplifies measurement noise and for weakly magnetic systems it can compromise estimation of a FORC distribution. Several processing schemes, typically based on local polynomial regression, have been developed to produce smoothed FORC distributions that suppress detrimental noise. As FORC analysis has become more quantitative, the smoothed distribution needs to be consistent with the measurement data from which it was estimated. This can be a challenging task even for expert users, who must subjectively adjust parameters that define the form and extent of smoothing until a satisfactory FORC distribution is obtained. For non-expert users, estimation of FORC distributions using inappropriate smoothing parameters can produce heavily distorted results corrupted by processing artifacts, which in turn can lead to spurious inferences concerning the magnetic system under investigation. We have developed a statistical machine learning framework based on probabilistic model comparison to guide estimation of FORC distributions. An intuitive approach is presented that reveals which regions of a FORC distribution may have been smoothed inappropriately. Our machine learning approach will objectively select an optimal FORC distribution probabilistically, which will automate the derivative estimation process for both expert and non-expert users.

Keywords: machine learning, First Order Reversal Curve, magnetic hysteresis, mixed second derivative

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[E] Oral | B (Biogeosciences) : B-PT Paleontology

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 201A 2F

[B-PT04] Biomineralization and the Geochemistry of Proxies

convener:Takashi Toyofuku(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Hiroshi Kitazato(Tokyo University of Marine Science and Technology (TUMSAT)), Jelle Bijma(Alfred-Wegener-Institut Helmholtz-Zentrum f?r Polar- und Meeresforschung), Kotaro Hirose(Faculty of Science & Engineering, Waseda University), Chairperson:Kotaro Hirose(Waseda University School of Creative Science and Engineering), Takashi Toyofuku

Biomineralization and the Geochemistry of Proxies - Biology, laboratory culture-experiments and their applications to the paleo-research -
In order to reconstruct the Earth climate system, marine paleoclimatologists resort to transfer functions or geochemical proxies, which are produced or affected by organisms. The relationships used for reconstructions are generally based on field calibrations or derived from laboratory experiments. The danger of these so-called empirical relationships is that they may be valid only within the restricted parameter space of their calibration. Application of proxy relationships to very different environmental settings (e.g. high vs. low latitude or glacial vs. interglacial) requires a mechanistic understanding of these relationships. Much progress can be expected by a better understanding of the biomineralization mechanisms and the incorporation of proxy signals.
In this session we facilitate contributions related to the biomineralization, calibration and validation of marine proxies from field study, laboratory culture experiment and paleo-environmental reconstruction.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[BPT04-01] Long term size changes of the Middle Miocene planktonic foraminifera in the eastern equatorial Pacific

★Invited Papers

*Takuma Suzuki[1], Hiroki Hayashi[1] (1.Shimane University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[BPT04-02] Mathematical models for the geochemical composition of foraminiferal calcium carbonate

*Jelle Bijma[1], Dieter Wolf-Gladrow[1] (1.Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[BPT04-03] Response of structurally substituted sulfur in foraminifera shells to glacial-interglacial changes: a 1.0-million-year record from the Ontong-Java Plateau

*Toshihiro Yoshimura[1], Yusuke Tamenori[2], Junichiro Kuroda[3], Azumi Kuroyanagi[4], Naohiko Ohkouchi[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Japan Synchrotron Radiation Research Institute, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Tohoku University Museum, Tohoku University)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[BPT04-04] Transcript assembly and quantification identify candidate genes for foraminiferal calcification

*Yurika Ujiie[1], Yoshiyuki Ishitani[2], Shun'ichi Ishii[3], Yukiko Nagai[3], Yoshihiro Takaki[3], Tetsuro Ikuta[3], Takashi Toyofuku[3] (1.Center for Advanced Marine Core Research, Kochi University, 2.Center for Computational Sciences, University of Tsukuba, 3.Japan Agency for Marine-Earth Science and Technology)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[BPT04-05] Characterization of cogwheel structures in foraminifera

★Invited Papers

*Inge van Dijk[1], Markus Raitzsch[2], Gernot Nehrke[1], Jelle Bijma[1] (1.Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung, Am Handelshafen 12, Bremerhaven 27570, Germany, 2.MARUM - Zentrum für Marine Umweltwissenschaften, Universität Bremen, Leobener Str., 28359 Bremen, Germany)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[BPT04-06] Benthic foraminiferal characterizations from the seascape point of view

*Hiroshi Kitazato[1] (1.Tokyo University of Marine Science and Technology (TUMSAT))

Long term size changes of the Middle Miocene planktonic foraminifera in the eastern equatorial Pacific

*Takuma Suzuki[1], Hiroki Hayashi[1]

1. Shimane University

Body size is a key morphological attribute which has fundamental and significance information. For paleobiologic study based on fossil records, classification depends mainly on morphology of hard tissue. Previous studies noted that the temporal reduction in dominant size was observed in several fossil records when the taxon faced mass extinction or strong biostress.

This phenomenon was termed as “Lilliput effect” and appears to be ubiquitous to extinction events and occurs not only within unicellular and multicellular but also terrestrial and marine organisms, therefore it has a potential to make clear what the relationship between organism response and environmental fluctuation.

Then, a size analysis to investigate the phenomenon requires a lot of individuals of single taxon, therefore microfossil characterized by rich and successive abundance is more valid material than macrofossil. Particularly, planktonic foraminifera shows accretion growth by a adding new chamber on its penultimate chamber, therefore the size well reflects the ontogenic pattern.

The core samples we used in this study were drilled at the Integrated Ocean Drilling Program (IODP) Sites U1337 and U1338 consisting of the Pacific Equatorial Age Transect (PEAT) project, which was planned in order to obtain the Cenozoic successive geologic record. The stratigraphic interval of approximately 400 million years in Middle Miocene (15–11 Ma) was used for this study. This interval includes the transition from the relatively warm face (MCO: Miocene Climatic Optimum) to the colder mode with the expansion of the Eastern Antarctica Ice Sheet (EAIE: 13.8 Ma).

Keywords: Planktonic Foraminifera, Size, Giantism, Middle Miocene Climatic Optimum, Eastern Antarctic Ice-sheet Expansion

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Long term diameter changing

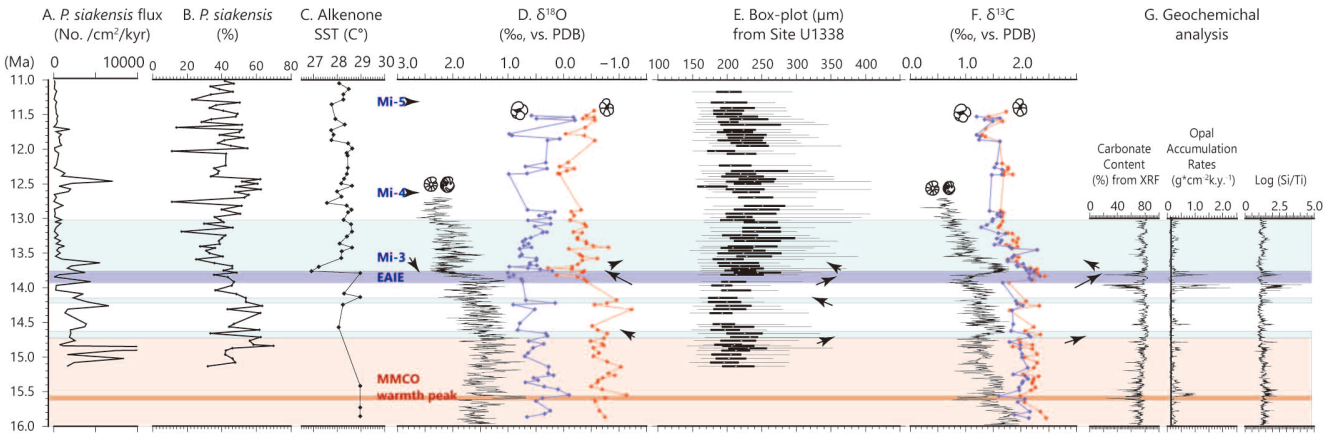

Fig.1 Temporal size changes are plotted with other previous data. A: Flux of *P. siakensis* at Site U1338 (Hayashi et al., 2013). B: Relative abundance of *P. siakensis* at Site U1338 (Hayashi et al., 2013). C: Alkenone SST data at Site U1338 (Rousselle et al., 2013). D: Stable oxygen isotope data. The black line represents benthic foraminiferal data at Site U1338 (Holbourn et al., 2014). The red line represents data for *P. siakensis* and the blue line does data for *Dentoglobigerina venezuelana* at Site U1337 (Matsui et al., 2017). E: Diameter of *P. siakensis* at Site U1338. F: Stable carbon isotope data. The color of each line is same as D. G: Geochemical data (Holbourn et al., 2014; Lyle et al., 2012).

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Mathematical models for the geochemical composition of foraminiferal calcium carbonate

*Jelle Bijma[1], Dieter Wolf-Gladrow[1]

1. Alfred-Wegener-Institut Helmholtz-Zentrum für Polar- und Meeresforschung

The isotopic compositions ($\delta^{11}B$, $\delta^{13}C$, $\delta^{18}O$) of foraminiferal calcium carbonate are used as paleo-proxies for pH, biological production, temperature or ice-volume. However, in order to interpret the observed isotopic values, one needs a process-based (`mechanistic´) understanding of the generation the proxy data. For this purpose, mathematical models have been developed. Because of missing detailed information about various processes involved in biomineralization these models were somewhat speculative despite their formulation based on physical and chemical principles. Application of these models in the framework of paleoceanographic simulations (generation of `simulated sediment cores´) can be used to test these models. I will discuss limitations of the models, open questions, and possible further developments.

Keywords: biomineralisation, foraminifer, geochemistry, numerical models

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Response of structurally substituted sulfur in foraminifera shells to glacial-interglacial changes: a 1.0-million-year record from the Ontong-Java Plateau

*Toshihiro Yoshimura[1], Yusuke Tamenori[2], Junichiro Kuroda[3], Azumi Kuroyanagi[4], Naohiko Ohkouchi[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Japan Synchrotron Radiation Research Institute, 3. Atmosphere and Ocean Research Institute, The University of Tokyo, 4. Tohoku University Museum, Tohoku University

During the Quaternary, the Earth’ s surface has experienced large changes in the extent of glaciation, sea-level, and temperature. The preservation of biogenic carbonates in deep-sea sediments reflects changes in deep-water circulation and in rates of production of carbonate and organic carbon in the surface ocean. The response of carbonate alkalinity to glacial-interglacial cycles provides important constraints on past oceanic carbon cycles. Because the relative activity of sulfate ions to carbonate ions in the calcifying fluids would influence sulfate incorporation into $CaCO_3$, sulfate contents (or sulfur to calcium ratio) have been proposed as a potential archive of carbonate ion concentrations. However, the preservation of some trace elements in biogenic carbonates is highly susceptible to physicochemical conditions of sedimentation, thus the spatiotemporal variability of sulfur proxy in foraminiferal calcite is still under debate. Here we show a 1.0-million-year record of structurally substituted sulfur in foraminifera shells from the Ontong-Java Plateau. For this study, we used a synchrotron source micro-X-ray fluorescence (μ-XRF) as well as *K*-edge XANES to show the sulfur content and local coordination environment in mixed-species foraminifera. All chambers of foraminiferal shells were physically broken in a glass vial and then ultrasonically cleaned in de-ionized water, methanol, H_2O_2 and $HClO_4$. The μ-XRF measurements were taken at a photon energy of 3000.0 eV with an acquisition time of 5 s. The ratios of sulfur to calcium is calibrated using carbonate reference standards. The XANES spectra suggested that the sulfur in foraminifera shells is predominantly in structurally substituted sulfate, and S/Ca ratios fluctuate between 1.0 and 1.5 mmol/mol. The glacial-interglacial cycles were not clearly defined in sulfur contents between 0.9-0.6 Ma, whereas after 0.6 Ma, the emergence of quasi-100 ka cycles was observed. To place the sulfur record into paleoceanographic context, we compare the data with water mass, carbon cycle, and the preservation of foraminiferal calcite in deep-sea sediments.

Keywords: glacial-interglacial cycle, sulfur, foraminifera

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Transcript assembly and quantification identify candidate genes for foraminiferal calcification

*Yurika Ujiie[1], Yoshiyuki Ishitani[2], Shun'ichi Ishii[3], Yukiko Nagai[3], Yoshihiro Takaki[3], Tetsuro Ikuta[3], Takashi Toyofuku[3]

1. Center for Advanced Marine Core Research, Kochi University, 2. Center for Computational Sciences, University of Tsukuba, 3. Japan Agency for Marine-Earth Science and Technology

Foraminifera, a major group of biomineralizing eukaryotes, have two important roles in paleo and modern Earth environments. Firstly, foraminifers produce a large amount of calcium carbonate in pelagic realm due to their widespread distributions and high-biomass over the world oceans. Their calcification could largely impact on the global biogeochemical cycleof both CO_2 and calcium. The second point is that the foraminiferal shells have been preserved in marine sediments with an excellent fossil record, leading to reconstruction of Earth environmental changes in the past. Because foraminifers uptake the extracellular CO_2 from ambient sea-water during the shell-forming, these shells record the chemical condition of the ocean at that time. Therefore, many scientists have paid attention to the mechanism of foraminiferal biomineralization. The precise cell observations during the shell-forming process mentioned that the calcium ion and inorganic carbon were excreted from vesicles in the cell. Such intracellular storages of indispensable elements for calcification concern non-equilibrium state of calcium ion between sea-water and the shells. Even such studies tackled the biomineralization process, they emphasized the necessity of understanding cellular metabolism for foraminiferal biomineralization.
In order to reveal biomineralizing mechanism of foraminifers, we here present the gene expression profiles during the foraminiferal calcification for the first time. We used cultured specimens of *Ammonia beccarii*, which have hyaline calcite, and applied comparative transcriptomic survey by using high-throughput mRNA sequencing (RNA-seq). We performed *de novo* assembly using ~67 million pair-end reads of mRNAs, and then mapped back the reads to the open read frames (ORFs) for calculating the expression levels. From the results, we identified the candidate genes for the calcification process; Ca^{2+} is transported through multiple ion channels from an extracellular region and pooled in vesicles. These Ca^{2+} seem to play important role for mitochondrial ATP synthesis. We also found the genes coding enzymes, which are related to generate bicarbonate in a cell and to release it to extracellular. In taking account of the studies of cell observations, the present study figured out transportations of ions and molecules for calcification.

Keywords: calcification, single-cell eukaryote, gene expression

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Characterization of cogwheel structures in foraminifera

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Studying biomineralization of foraminifera has become more popular over the last decade and is increasingly directed towards its linkage with element incorporation and isotope fractionation. The next step forward, is to investigate the “systematics” between structure (biomechanical constraints) and chemistry (biochemical constraints). We aim to catalogue species-specific variations in ultra-structures of foraminiferal shells, so-called cogwheels. These features, measuring in general 2-10 μm in diameter, vary greatly between species and become visible after slightly etching the surface of the shell. By using SEM pictures and the software “ImageJ” we can select and automatically measure different parameters of these cogwheels as well as of the pores. These structures will be compared within individuals (e.g. different chambers) as well as between different species. The ultimate goal is to link chemical (e.g. Mg content) to physical (e.g. shape and size) cogwheel properties. By investigating these combinations systematically and by linking them to phylogeny, we hope to find evolutionary patterns and to get insight into calcification mechanisms and geochemical controls. This will improve our mechanistic understanding of proxy incorporation and help to better interpret climate and environmental foraminiferal archives.

Keywords: Biomineralization, Foraminifera

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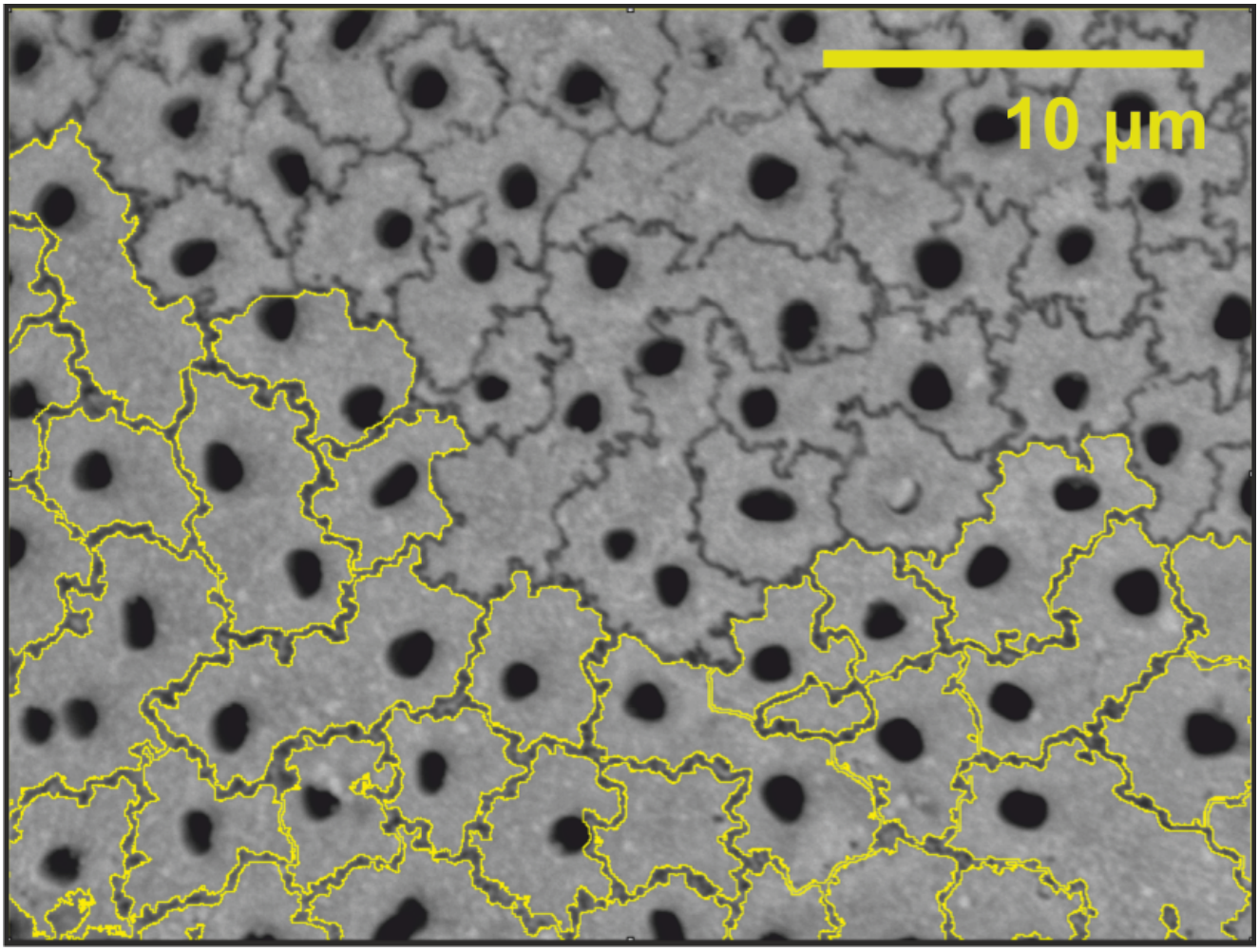

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Benthic foraminiferal characterizations from the seascape point of view

*Hiroshi Kitazato[1]

1. Tokyo University of Marine Science and Technology (TUMSAT)

Benthic foraminifers dwell in bottom environments with habitat segregations. For instance, benthic foraminiferal species live on algal species according to exixting microhabitats such as fronds or thali of algae, or sediments in between fronds. Benthic foraminiferal species that are living with microhabitat segregations show specific characteristics such as feeding behaviors, living positions and test growth patterns according to microhabitat specific environmental characters . These characters are strongly affected by microhabitat specific microenvironments. During my presentation, I will compile group of microhabitats and their microenvironmental characters (Kitazato, 1994). Then, I try to explain how microhabitats segregation relate strongly with habitat specific adaptational tactics of foraminiferal species.
These landscape ecological approaches may have made clear species specific functional ecology of foraminiferal species groups.

Keywords: foraminifers, habitat segregation, seascape in the sea

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[E] Oral | B (Biogeosciences)：B-PT Paleontology

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 201A 2F

[B-PT04] Biomineralization and the Geochemistry of Proxies

convener:Takashi Toyofuku(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Hiroshi Kitazato(Tokyo University of Marine Science and Technology (TUMSAT)), Jelle Bijma(Alfred-Wegener-Institut Helmholtz-Zentrum f?r Polar- und Meeresforschung), Kotaro Hirose(Faculty of Science & Engineering, Waseda University), Chairperson:Jelle Bijma(AWI), 北里 洋

Biomineralization and the Geochemistry of Proxies - Biology, laboratory culture-experiments and their applications to the paleo-research -
In order to reconstruct the Earth climate system, marine paleoclimatologists resort to transfer functions or geochemical proxies, which are produced or affected by organisms. The relationships used for reconstructions are generally based on field calibrations or derived from laboratory experiments. The danger of these so-called empirical relationships is that they may be valid only within the restricted parameter space of their calibration. Application of proxy relationships to very different environmental settings (e.g. high vs. low latitude or glacial vs. interglacial) requires a mechanistic understanding of these relationships. Much progress can be expected by a better understanding of the biomineralization mechanisms and the incorporation of proxy signals.
In this session we facilitate contributions related to the biomineralization, calibration and validation of marine proxies from field study, laboratory culture experiment and paleo-environmental reconstruction.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[BPT04-07] Skeleton microstructures of aposymbiotic scleractinian coral cultured in seawater with various Mg/Ca ratios

*Satoko Motai[1], Naotaka Tomioka[1], Jun Kawano[2], Saki Harii[3], Takaya Nagai[2], Tsuyoshi Watanabe[2], Yu Kodama[4], Motoo Ito[1] (1.Japan Agency for Marine-Earth and Technology, 2.Hokkaido University, 3.University of the Ryukyus, 4.Marine Works Japan)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[BPT04-08] Skeletal formation of scleractinian corals in response to Mg/Ca fluctuation

*Tomihiko Higuchi[1], Ikuko Yuyama[2] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.University of Tsukuba)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[BPT04-09] **Inter-specific variations in trace element concentrations of modern brachiopod shells collected from Otsuchi Bay, Japan**

*Takuya Nishio[1], Hideko Takayanagi[1], Ryuji Asami[1], Ryuichi Shinjo[2], Koshi Yamamoto[3], Yasufumi Iryu[1] (1.Institute of Geology and Paleontology, Graduate School of Science, Tohoku University, 2.Graduate School of Engineering and Science, University of the Ryukyus, 3.Graduate School of Environmental Studies, Nagoya University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[BPT04-10] Trace element concentrations of sub-tropical modern brachiopod *Basiliola lucida* collected off Okinawa-jima, Japan

*Hideko Takayanagi[1], Tomoko Tochigi[1], Ryuji Asami[1], Ryuichi Shinjo[2], Takuya Itaki[3], Yasufumi Iryu[1] (1.Tohoku University, 2.University of the Ryukyus, 3.Advanced Industrial Science and Technology (AIST))

11:45 AM - 12:05 PM JST | 2:45 AM - 3:05 AM UTC

[BPT04-11] Structural difference between phaeodarians and radiolarians (unicellular zooplankton)

★Invited Papers

*Yasuhide Nakamura[1], Rie Hori, S.[2], Akihiro Tuji[1], Hiroaki Ohfuji[2], Noritoshi Suzuki[3], Katsunori Kimoto[4] (1.National Museum of Nature and Science, 2.Ehime University, 3.Tohoku University, 4.JAMSTEC)

12:05 PM - 12:15 PM JST | 3:05 AM - 3:15 AM UTC
Discussion

Skeleton microstructures of aposymbiotic scleractinian coral cultured in seawater with various Mg/Ca ratios

*Satoko Motai[1], Naotaka Tomioka[1], Jun Kawano[2], Saki Harii[3], Takaya Nagai[2], Tsuyoshi Watanabe[2], Yu Kodama[4], Motoo Ito[1]

1. Japan Agency for Marine-Earth and Technology, 2. Hokkaido University, 3. University of the Ryukyus, 4. Marine Works Japan

Skeletons of present-day reef-building scleractinian corals consist of aragonite which is one of polymorphs of calcium carbonate. Meanwhile, in the Late Cretaceous, scleractinian corals with two different skeletal mineralogies of aragonite and calcite have been identified (Stolarski et al., 2007; Janiszewska et al., 2017). Although a Cretaceous seawater Mg/Ca molar ratio (*m*Mg/Ca), which affects polymorph selection, of ~1 is a possible reason as to why corals formed calcitic skeletons, previous studies have shown that aragonite was still a major phase in modern symbiotic coral skeletons in a pseudo-Cretaceous sea (Reis et al., 2006; Higuchi et al., 2014). There should be other factors to explanation for the existence of calcite skeletons in such a sea. Our previous work (Motai et al., 2017) has reported that corals form calcite skeleton without a symbiotic relationship between the coral host and zooxanthellae in a pseudo-Cretaceous sea with *m*Mg/Ca ratios of ~1.

Juveniles of modern scleractinian corals (*Acropora* spp.) were cultured without symbionts (Motai et al., 2017). At approximately 26 ˚C, aposymbiotic corals formed entirely aragonite skeleton in the present sea with an *m*Mg/Ca ratio of ~5, whereas aposymbiotic corals formed entirely calcite skeleton in a pseudo-Cretaceous sea with an *m*Mg/Ca ratio of <1. Both aragonite and calcite skeletons have typical structures same as skeleton of symbiotic consisted of basal plates, septa, costae, and walls, in sub-millimeter scale under an optical microscope. To retrieve the effectiveness of different mineral phases on coral skeletal morphology in more fine scale, we have carried out textural observation utilizing a scanning electron microscopy for μm-scale area and a transmission electron microscopy for sub-μm scale area.

The aragonite skeleton consists of granular and needle-like grains less than ~1 μm. The needle-like grains are radially oriented from aggregates of granular grains. The similar microstructures are previously observed in skeletons of symbiotic coral. The components of granular and needle-like grains are called as centers of calcification (COCs) and fibers, respectively. On the other hand, calcite skeleton consists of needle-like grains with larger than ~2 μm in length and shows neither COCs nor fibers components. The difference in grain size and shape between aragonite and calcite skeletons affects their surface morphology: regular shingled thickening deposits with the width ~10 μm appear in aragonite skeletons, whereas no such morphologies are observed in calcite skeletons. Nevertheless, both of aragonite and calcite skeleton of aposymbiotic corals form similar skeletal structure to symbiotic coral skeletons. Therefore, scleractinian corals may control forming their typical skeletal structures despite of different textures and morphologies caused by different mineral phases.

Stolarski J., Meibom A., Przenioslo R., Mazur M., 2007, Science, 318:92–94
Janiszewska K., Mazur M., Escrig S., Meibom A., Stolarski J., 2017, Geology, 45:319–322
Reis J.B., Stanley S.M., Hardie L.A., 2006, Geology, 34:525–528
Higuchi T., Fujimura H., Yuyama I., Harii S., Agostini S., Oomori T., 2014, PLoS One 9014

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Motai S., Kawano J., Harii S., Watanabe T., Nagai T., 2017, JpGU-AGU Joint Meeting

Keywords: reef-building coral, biomineralization, symbiotic algae, aragonite, calcite

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Skeletal formation of scleractinian corals in response to Mg/Ca fluctuation

*Tomihiko Higuchi[1], Ikuko Yuyama[2]

1. Atmosphere and Ocean Research Institute, The University of Tokyo, 2. University of Tsukuba

Although coral skeletons generally comprise aragonite crystals, changes in the molar Mg/Ca ratio (*m* Mg/Ca) in seawater result in the incorporation of calcite crystals (Higuchi et al. 2014, Plos one). Also, we found temperature-dependent aragonite and calcite formation by scleractinian corals in low *m*Mg/Ca seawater (Higuchi et al. 2017, Geology). Corals produced more aragonite than formed in inorganic $CaCO_3$ precipitation experiments under the same conditions, except at 19 ˚C. Although the aragonite content reflected the results of the abiotic experiments at 19 ˚C, it is suggested that aragonitic scleractinian corals controlled skeletal formation biologically under low *m*Mg/Ca conditions at higher temperature. The mechanism of formation of aragonite and calcite crystals in coral skeletons was therefore investigated by RNA-seq analysis, using early growth stage calcite (*m*Mg/Ca=0.5) and aragonite (*m*Mg/Ca=5.2)-based corals (Yuyama and Higuchi, submitted). As a result, 1287 genes were up-regulated and 748 down-regulated in calcite-based corals. In particular, 91 skeletogenesis-related genes, such as Collagen alpha and Galaxin, were detected as up-regulated genes and 15, such as Hemicentin, were down-regulated, in low-Mg/Ca conditions. Since the number of down-regulated genes associated with the skeletal organic matrix of aragonite skeletons was much lower than that of up-regulated genes, it is thought that corals actively cause the skeletal organic matrix to construct an aragonite skeleton in low-Mg/Ca conditions. The results also indicated that different types of skeletal organic matrix proteins, extracellular matrix proteins and calcium ion binding proteins changed their expression in both calcite-formed corals and normal corals, suggesting that the composition of these proteins could be a key factor in the selective formation of aragonite or calcite $CaCO_3$.

Keywords: Aragonite-Calcite, scleractinian coral, Mg/Ca fluctuation

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Inter-specific variations in trace element concentrations of modern brachiopod shells collected from Otsuchi Bay, Japan

*Takuya Nishio[1], Hideko Takayanagi[1], Ryuji Asami[1], Ryuichi Shinjo[2], Koshi Yamamoto[3], Yasufumi Iryu[1]

1. Institute of Geology and Paleontology, Graduate School of Science, Tohoku University, 2. Graduate School of Engineering and Science, University of the Ryukyus, 3. Graduate School of Environmental Studies, Nagoya University

Carbon- ($\delta^{13}C$) and oxygen-($\delta^{18}O$) isotope composition and trace element to calcium ratios (Me/Ca; e.g., Mg/Ca and Sr/Ca) in biogenic carbonates have been used as a powerful tool for reconstructing paleoceanographic and paleoenvironmental conditions throughout the Phanerozoic. Rhynchonelliformea brachiopods, hereafter called “brachiopod”, are regarded as one of the excellent archives for the conditions because of (1) their extensive fossil records from the early Cambrian onwards, (2) their dense, low-magnesium calcite shells less susceptible to diagenetic alteration than aragonitic precipitates of marine calicifiers, and (3) the occurrence of modern analoguesin the oceans.For these reasons, $\delta^{13}C$ and $\delta^{18}O$ values of fossil brachiopod shells have been served as a major data source in many studies on paleoenvironments, especially those in the Paleozoic and Mesozoic. In contrast, Me/Ca in brachiopod shells has not been used as paleoenvironmental indicators because the relationship between shell chemistry and seawater composition and physical properties (e.g., temperature, salinity) are not well understood. This is at least partly due to difficulties in obtaining time-series of Me/Ca from modern brachiopod shells to compare directly with those in seawater chemistry (pH and carbonate system as well as Me/Ca) and the oceanographic properties at their growth sites.
We investigated inter-specific variations in Mg/Ca, Sr/Ca, Mn/Ca, and Fe/Ca in the shells of four modern brachiopod species collected from two different water depths in Otsuchi Bay, Japan, and established a new technique for converting distance domain Me/Ca profiles of the ontogenetic-series samples to the Me/Ca time-series. Mg/Ca of *Terebratulina crossei*is higher than that of the other species (*Laqueus blanfordi*,*Laqueus rubellus*, and *Terebratalia coreanica*). Significant correlations are found between Mg/Ca and $\delta^{18}O$ values of some samples. If the correlations are statiscally significant, regression equations established for Mg/Ca and seawater temperatures for brachiopod shells have steeper slopes and higher intercepts than those for foraminiferal tests. Sr/Ca profiles are likely different in their patterns among species even though they live at the same water depth. Mn/Ca and Fe/Ca of the all species are verylow or below detection limits.

Keywords: Modern brachiopod, Trace element concentration, Paleoenvironmental proxy, Otsuchi Bay

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Trace element concentrations of sub-tropical modern brachiopod *Basiliola lucida* collected off Okinawa-jima, Japan

*Hideko Takayanagi[1], Tomoko Tochigi[1], Ryuji Asami[1], Ryuichi Shinjo[2], Takuya Itaki[3], Yasufumi Iryu[1]

1. Tohoku University, 2. University of the Ryukyus, 3. Advanced Industrial Science and Technology (AIST)

Trace element concentrations in biogenic carbonates have been widely used as an indicator for paleoceanographic conditions, such as seawater temperature, chemical and isotopic composition, and oceanic carbonate system. Since calcium carbonates ($CaCO_3$) are easy to treat and handle for their geochemical analyses, the combined use of trace element and isotopic ratios (e.g., Me/Ca and $\delta^{18}O$) analyzed from the same powder samples from calcareous fossils provides multi-proxy constraints on paleoenvironmental reconstructions. Brachiopods, one of the most crucial marine calcifiers throughout the Phanerozoic, have been regarded as key taxa for expanding our knowledge on the evolution of Earth's oceans and climate. Brachiopod-based paleoenvironments, however, have been mainly reconstructed from carbon and oxygen isotope composition, and the use of their trace element concentrations has been limited. Although some studies were conducted on within-shell variability of trace elements in modern brachiopod shells, it is still uncertain what environmental and/or physiological factors control the incorporation of trace elements into the shells and how precisely the shells record environmental signals of ambient seawater. In order to resolve these questions, it is necessary to compare trace element ratios of modern brachiopod shells with those in seawater along with oceanographic properties at the brachiopod growth site. This study investigates trace element concentrations in shells of a sub-tropical modern brachiopod, *Basiliola lucida*, collected to the west of Okinawa-jima, Ryukyu Islands, southwestern Japan. A previous study indicates no biological controls on carbon and oxygen isotope compositions of *B. lucida* shells. Since a large amount data were obtained on oceanographic conditions and seawater chemistry by scientific cruises of the Geological Survey of Japan of the National Institute of Advanced Industrial Science and Technology (AIST/GSJ) from this region, it is expected that we can specify primary factor(s) controlling the incorporation of trace elements into brachiopod shells.

Keywords: Brachiopoda, Trace element concentrations, Ryukyu Islands, Paleoenvironmental proxy

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Structural difference between phaeodarians and radiolarians (unicellular zooplankton)

*Yasuhide Nakamura[1], Rie Hori, S.[2], Akihiro Tuji[1], Hiroaki Ohfuji[2], Noritoshi Suzuki[3], Katsunori Kimoto[4]

1. National Museum of Nature and Science, 2. Ehime University, 3. Tohoku University, 4. JAMSTEC

Radiolaria, Foraminifera and Phaeodaria are classified to the supergroup Rhizaria. Most of radiolarians and phaeodarians commonly possess skeletons made of amorphous silica ($SiO_2 \cdot nH_2O$), and the overall appearance of some phaeodarians is similar to that of radiolarians. Previous studies, however, revealed the structural difference among the two groups: Phaeodaria generally have spaces inside of the skeleton, and its fine structure is porous. Whereas, Spumellaria (Radiolaria) have solid skeleton, and there are no spaces within the skeleton (Takahashi & Hurd 2008, Nakamura et al. 2018). This study further examines the structural distinction among these two rhizarians groups from the viewpoint of ultrafine and overall structures.
Zooplankton were sampled in from 2011 to 2018 at ca. 20 stations in the North Pacific and the Mediterranean Sea. Phaeodarians and radiolarians were picked up from the samples and identified by observing their morphology. Individual specimens were then analyzed by the following three methods: (1) Thin cross-sections of ca. 70–200 nm were prepared, and the ultrafine structures were observed with a Transmission Electron Microscope (TEM). (2) The framework of the whole skeleton was visualized with a Micro-Xray Computed Tomography (MXCT). (3) Living radiolarians and phaeodarians were cultured with HCK-123, a fluorescent reagent specifically reacting to silica-precipitating parts, and the skeleton formation process was observed.
(1) Detailed observation of thin cross-sections revealed that the skeletons of radiolarians (including the orders Nassellaria and Collodaria) had no space within the skeleton, while the skeletons of all the analyzed phaeodarians were porous. (2) This result was confirmed by the MXCT analysis. Radiolarian skeleton did not contain any spaces, while numerous spaces were observed inside of the phaeodarian skeleton. (3) The culture experiment clarified that radiolarians form their skeleton from the central part of the cell. However, phaeodarians first create new skeletons (daughter cells) with almost the same size as that of the mother cell. The new skeleton then becomes thicker by adding silica from the inside. One mother cell produced four daughter cells within 12 hours at the fastest, suggesting that phaeodarians can create new skeletons faster than radiolarians. Considering also the occasional high biomass of phaeodarians, this group would be able to rapidly increase their number when the environment becomes preferable.

Keywords: Cercozoa, protist, biomineralization, silica, plankton

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[E] Poster | B (Biogeosciences)：B-PT Paleontology

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_22

[B-PT04] Biomineralization and the Geochemistry of Proxies

convener:Takashi Toyofuku(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Hiroshi Kitazato(Tokyo University of Marine Science and Technology (TUMSAT)), Jelle Bijma(Alfred-Wegener-Institut Helmholtz-Zentrum f?r Polar- und Meeresforschung), Kotaro Hirose(Faculty of Science & Engineering, Waseda University)

Biomineralization and the Geochemistry of Proxies - Biology, laboratory culture-experiments and their applications to the paleo-research -
In order to reconstruct the Earth climate system, marine paleoclimatologists resort to transfer functions or geochemical proxies, which are produced or affected by organisms. The relationships used for reconstructions are generally based on field calibrations or derived from laboratory experiments. The danger of these so-called empirical relationships is that they may be valid only within the restricted parameter space of their calibration. Application of proxy relationships to very different environmental settings (e.g. high vs. low latitude or glacial vs. interglacial) requires a mechanistic understanding of these relationships. Much progress can be expected by a better understanding of the biomineralization mechanisms and the incorporation of proxy signals.
In this session we facilitate contributions related to the biomineralization, calibration and validation of marine proxies from field study, laboratory culture experiment and paleo-environmental reconstruction.

[BPT04-P01] Living (stained) benthic foraminifera in the West-Gironde mud patch (Bay of Biscay, France): An ongoing survey for the European Community.

*Christophe Fontanier[1,2], Bruno Deflandre[1], Sylvain Rigaud[3], Sabine Schmidt[1], Bastien Lamarque[1], Pascal Lebleu[1], Dominique Poirier[1], Antoine Grémare[1] (1. Bordeaux University, EPOC Laboratory, UMR CNRS 5805 OASU, F-33615 Pessac, FRANCE, 2.FORAM Research Group, F-49140 Villevêque, FRANCE, 3.Nîmes University, GIS Laboratory, EA 7352 CHROME, F-30035 Nïmes, FRANCE)

[BPT04-P02] Biomonitoring in the Cassidaigne Canyon (NW Mediterranean): the resilience and recovery of deep-sea benthic foraminifera at a bauxite industrial waste site

*Pauline Duros[1], Christophe Fontanier[1,2,3], Briony Mamo[4,5], Deborah Mille[6], Olivier Herlory[6] (1.FORAM Research Group, F-49140 Villevêque, FRANCE, 2.Bordeaux University, EPOC Laboratory, UMR CNRS 5805 OASU, F-33615 Pessac, FRANCE, 3.Angers University, 4 boulevard Lavoisier, F-49000 Angers, FRANCE., 4.School of Biological Sciences, University of Hong Kong, Pokfulam Road Sai Wan, Hong Kong SAR, CHINA. , 5.Department of Biology, Macquarie University, North Ryde, NSW, 2109, AUSTRALIA., 6.CREOCEAN, Agence PACA Corse, 230 Avenue de Rome, Valparc-Bât B, F-83500 La Seyne sur Mer, FRANCE.)

[BPT04-P03] Comparison between assemblages of diatom fossil and biomarkers in surface sediments from Seto Inland Sea

*Kotaro Hirose[1], Hideto Nakamura[2], Takuto Ando[4], Satoshi Asaoka[3], Ken Sawada[5] (1.Faculty of Science & Engineering, Waseda University, 2.Faculty of Science, Osaka City University, 3.Research Center for Inland Seas & Department of Planetology, Kobe University, 4.Arctic Research Center, Hokkaido University, 5.Department of Earth & Planetary Science, Faculty of Science, Hokkaido University)

[BPT04-P04] Combined impacts of ocean acidification and desalination: culture experiments on the coastal species *Ammonia* sp. and *Elphidium crispum*

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[BPT04-P05] Effects on larger benthic foraminiferal shell density under global warming

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[BPT04-P06] Estimation of the calcification rate of foraminifera -exceptionally fast extending of the shell-

*Yukiko Nagai[1,2], Katsuyuki Uematsu[3], Takashi Toyofuku[2,4] (1.National Museum of Nature and Science of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Marine Works Japan Enterprise, 4.Tokyo university of Marine Science and Technology)

[BPT04-P07] Estimation of foraminiferal calcification process from live imaging and FIB-SEM approach

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[BPT04-P08] Toward a better understanding of planktic foraminiferal proxies: Are they photosymbiotic or not?

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[BPT04-P09] Evaluation of geochemistry in hypercalcified demosponges as a paleoceanographic proxy

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Living (stained) benthic foraminifera in the West-Gironde mud patch (Bay of Biscay, France): An ongoing survey for the European Community.

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During an environmental survey performed in summer 2017 (JERICObent-2 Cruise), living (stained) benthic foraminiferal faunas were investigated at 7 stations sampled within the West-Gironde mud patch, a mud belt located on the marine shelf in front of the Gironde River (Bay of Biscay, France). This study area is really strategic for local fisheries since substantial marine resources (demersal fishes, shrimps...) are easily accessible for coastal fishermen. Moreover, the mud belt is considered an important hotspot for marine biodiversity as far as food (i.e. sedimentary organic matter), which is naturally abundant there, could sustain an assumedly enhanced heterogeneity of benthic habitats for various taxon. In the framework of the European project JERICONext (ID 654410), we have been studying biological (prokaryotes, benthic meiofauna and macrofauna), sedimentary and geochemical patterns of mud-flat ecosystems in order to better understand how both spatial and temporal variability of riverine regime and coastal hydrodynamics impact the dynamics of the benthic life, especially foraminifera. Stations investigated in this presentation are located between 39 and 69 m water depth from the inner shelf to the mid-shelf. At most sites, surface sediment is characterized by clay-silt facies more or less enriched in organic matter. Oxygen penetration depth within the sediment is less than 7±3 mm. Foraminiferal simple diversity (S) presents relatively moderate values ranging between 15 and 35 taxa. According to Shannon Index H' and Rarefaction Index ES(100), foraminiferal diversity tends to slightly increase with water depth. This trend is supported by *Eggerelloides scabrus;* its contribution decreases from the shallower stations (~50%) of the proximal mud patch (<55 m depth) to the deeper stations (<30%) of the distal mud patch (>55 m depth). This agglutinated species is generally considered a reliable bio-indicator of organic-matter enriched sediment in front of river mouths. It is noteworthy that the shallowest station (station 1, 39 m) is also characterised by the exclusive contribution of *Quinqueloculina lata/laevigata* and *Ammonia beccarii,* which are both typical of inner-shelf environments. There, surface sediment is made of fine sand. The deeper stations (>55 m depth) located in the distal mud patch are characterised by a remarkable contribution (~30%) of *Pseudoeponides falsobeccarii* and Buliminids (~30% respectively). They are accompanied by *Rectuvigerina phlegeri* and *Nonion fabum*, which are typical of mid- and outer-shelf ecosystems. The contribution of Buliminids underline the gradual increase of sedimentary organic content (>1.2% DW) with water depth.

Keywords: Living Benthic Foraminifera, Mud Belt, Environmental Spatial Variability, Sedimentary Organic Matter, Oxygenation Level

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Biomonitoring in the Cassidaigne Canyon (NW Mediterranean): the resilience and recovery of deep-sea benthic foraminifera at a bauxite industrial waste site

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During an environmental survey performed in autumn 2016, living (stained) benthic foraminiferal faunas were investigated at 16 stations sampled within the Cassidaigne Canyon (NW Mediterranean Sea) and surrounding area. For many decades, industrial bauxite residues of red mud have drained into the canyon via a submarine pipe, causing physical disturbance and chemical contamination. In January 2016, solid waste disposal ceased and was replaced with the dumping of a low-density liquid effluent. Stations investigated in this paper are located between 265–2500 m water depth from the shelf break to the deeper basin and from a distance between 4–70 km from the pipe outlet. At many sites, surface sediment is characterized by historical deposits of red mud and their geochemical imprints. Our ecological observations at the 725 m-depth station closest to the Cassidaigne Canyon submarine pipe show the highest concentration of the opportunistic and stress-tolerant species *Bulimina marginata* d' Orbigny, 1826, commonly identified as a recolonizer of disturbed areas. At the other fifteen stations, foraminiferal standing stocks and simple diversity (S) decrease with decreasing food input to the seafloor and increasing water depth. There, foraminiferal composition is characterized by a minor contribution of stress-tolerant species and echoes the overall meso-oligotrophic patterns of a relatively stable ecosystem. Our study clearly shows that in September 2016, 10 months after a historical shift in discharged industrial wastes (from dense red mud to liquid effluent), foraminiferal diversity close to the pipe outlet in the Cassidaigne Canyon remains altered, but appears to be slowly recovering.

Keywords: Benthic foraminifera, Bauxite residues, Cassidaigne Canyon, Resilience

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Comparison between assemblages of diatom fossil and biomarkers in surface sediments from Seto Inland Sea

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We investigate the fossil diatom abundances and biomarker concentrations in marine sediment to assess their relationships. 14 sample of surface (uppermost 5 cm of sea bottom) sediments are taken in 5 areas (Aki-nada Bay, Hiuchi-nada Bay, Harimanada-Bay, Osaka Bay and Kii Strait) of Seto Inland Seas in July 2015. Additional 8 samples are taken in Harimanada-Bay in October 2015. Although the precise age of the core has not been determined yet, it could be deposited within 10 years, according to the sedimentation rates by previous study (Yasuhara et al., 2007).
Diatom species such as small *Thalassiosira*spp., *skeletonema costatum*, resting spore of *Chaetoceros* spp. and *Neodelphyneis pelagica*, which were reported by previous study (Hirose et al., 2008), are observed as the dominant taxa in all samples. *Rhizosolenia* spp. and *Pleurosigma* spp., known HBI producers, were occurred in low proportions. As specific diatom biomarkers, we identified C25 di- and tri-unsaturated highly branched isoprenoids (HBIs), along with relatively minor amount of C25 and C35 cyclic HBIs. Total abundances of diatom valves and HBIs were generally correlated, probably reflecting variations of diatom production. Meanwhile, Aki-bay and some samples of Harima-nada Bay were characterized with relatively low abundance of HBIs relative to valves. In these area, focused analysis on the minor diatom taxa would be needed to provide quantitative dataset to discuss further relation of HBIs and produces and their spatial distribution.

Keywords: diatom assemblage, diatom biomarkers, HBIs, surface sediment, Seto Inland Seas

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Combined impacts of ocean acidification and desalination: culture experiments on the coastal species *Ammonia* sp. and *Elphidium crispum*

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Coastal areas display natural large environmental variability such as frequent changes in salinity, pH, and carbonate chemistry. Anthropogenic impacts –especially ocean acidification –increase this variability, which may affect the living conditions of coastal species, particularly, calcifiers, such as foraminifera.

The purpose of this study was to evaluate the combined effect of two typical environmental stressors on the coast - salinity and pH –on calcifying organisms. We performed culture experiments on living benthic foraminifera to study the combined effects of lowered pH and salinity on the calcification abilities and survival of the coastal, calcitic species Ammonia sp. and *Elphidium crispum*.

We found that these two species could tolerate low pH and low salinity, which reflects the environmental variations in their natural habitats. However, in open ocean conditions (salinity ~35) and lower pH treatment, the species displayed resistance to test dissolution for a longer time than in brackish conditions (salinity ~5 to 20). Moreover, the response of foraminifera to the different treatments was species-specific, and *Ammonia* sp. appeared more resistant than *E. crispum* when placed in the same conditions of pH and salinity. We also observed living dissolved specimens of juveniles *Ammonia* sp. under the combined effect of low pH and very low salinity, and we showed that desalination is one cause for the decalcification. However, they were not able to recalcify when returned to higher salinities, probably due to a sensitive balance in environmental parameters. Finally, we highlight the ability of foraminifera to survive under $\Omega calc < 1$, and that high salinity and $[Ca^{2+}]$ as building blocks are crucial for the foraminiferal calcification process.

We conclude that coastal benthic foraminifera will not immediately be affected by ocean acidification, but rather by a combination of decreasing salinity and lowered pH.

Keywords: Coastal ocean acidification, Desalination, Culture experiment, Benthic foraminifera, Calcification process

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Effects on larger benthic foraminiferal shell density under global warming

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On the recent ocean environment, due to progresses of global warming and ocean acidification, it is concerned that calcifying organisms will be seriously affected from these environmental changes. Larger benthic foraminifers (LBFs) build calcium carbonate shells. Their carbonate productivity is the third highest rate in coral reef area next to reef corals and calcareous algae. Therefore, it is important to clarify the relationship between ocean environmental changes and the response of LBFs for predicting future ocean environment including carbon cycle. Based upon test diameter and shell weight, previous studies expected how foraminifers react to sea water conditions where they are living. However, in those reports, it is still not clear whether the changing of shell weight is due to changing of shell thickness (shell volume) or shell density, also whether that changing is depending sea water temperature or acidity. Thus, this study was performed for clarifying the relationships between water temperature and LBFs shell parameters with laboratory experiments and means of micro computed tomography (CT).

In this study, we cultured the LBF *Sorites orbiculus* in filtered sea water until reproduction. Soon after *S. orbiculus* reproduced, clonal individuals from same mother individual were picked and separated into seven groups. One group was selected as initial stage sample, and other six groups were provided for culture experiments. We cultured each groups under six different temperature conditions (19, 21, 23, 25, 27 and 29 ˚C). Because clonal specimens were reproduced asexually from same individual, it was expected the genetic factors were kept to a minimum. We used micro CT to investigate mean CT number (proxy of density), shell volume, test diameter and chamber number of every clonal specimen after culturing. The results show the high correlation of mean CT number with temperature in contrast to the correlation of shell volume and temperature. This suggests changing in temperature of sea water causes shell density difference, furthermore, LBFs build the higher density shell in the higher temperature as long as they lives in 19 to 29 C˚ environment.

Keywords: Larger benthic foraminifer, shell density, micro CT, laboratory experiments, global warming

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Estimation of the calcification rate of foraminifera -exceptionally fast extending of the shell-

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The process of biomineralization of foraminiferal test is essential for its characteristic morphogenesis and the composition of element and isotope to be taken in is used also as paleo environmental proxy, numerous studies have been approched to reveal the mechanism of shell formation. However, how fast the foraminifera calicification and how much calcium carbonate deposits depends on the species, which is not well understood in most species.
The foraminifera *Spirillina vivipara* does not form a chamber, but elongate a tubular test spirally with their cytoplasmic growth. *Spirillina vivipara* is also known to be rapidly changing generations that can be reproduced in a several days after division of mother cells (Myers, 1936). From our current observations, it was also found that the shell formation is repeatedly carried out in the day, and the elongation rate of the shell is very fast. Therefore, in this study, Spirillina vivipara was used to estimate calcification rate.
In this presentation, we report on the fastest shell extending rate in foraminifera.

Keywords: Calcification, foraminifera, FIB-SEM

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Estimation of foraminiferal calcification process from live imaging and FIB-SEM approach

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Calcareous foraminifera have been thought a major carbonate producer in ocean. Their tests (shells) are fundamental tools as paleo-environmental indicators in various studies because their calcareous tests have been archived as numerous fossils in sediment for geologic time and various environmental information are brought by faunal structure, shell morphology and geochemical compsitions of calccitic test. The other hand, the calcification process itself is interested for us. Pseudopodia sticking out into sea water build organic templates in the form of chamber. Calcium carbonate is precipitated on the both side of template within several hours. Calcium and carbonate are fixed at there by foraminiferal biological process. The newly added chamber wall was flexible in a first day, the chamber solidified in a few days and became a solid test. It is very interesting to record this process in video. Our studies showed the variable change of pH and Ca during the biomineralization of foraminifera by the application of fluorescent indicators (e.g. Toyofuku et al., 2017). Recently, we also apply the method to clear cut the site of calcification under SEM by focused ion beam (FIB-SEM)(Nagai et al., 2018). The nano-scale fine structures have been revealed the distribution of soft orgnic structures (i.e. pseudopodia) and hard tissue (precipitated calium carbonate)by this observation.

Keywords: calcification, foraminifera, imaging

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Toward a better understanding of planktic foraminiferal proxies: Are they photosymbiotic or not?

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Geochemistry of planktic foraminiferal tests is an important archive to understand paleoenvironment. However, many biotic factors can affect the geochemical composition and thus may lead misinterpretation of the proxy signals. Photosymbiosis (endosymbiosis with autotrophic algae) is thought to give specific effects on foraminiferal test geochemistry such as $\delta^{13}C$ due to photosynthetic activity of the symbionts. This is because photosynthesis can alter the geochemical condition of the vicinity of the foraminiferal test where calcification takes place, and eventually elevate the $\delta^{13}C$ of the test. Therefore, whether foraminiferal species have photosymbiotic ecology or not, and how active the photosynthesis is are important information for precise paleoenvironmental reconstructions. However, photosymbiotic information of planktic foraminifers is still limited even for extant species which are often utilized to generate proxy records.
In this study, we investigated 30 species of modern planktic foraminifers covering four families; Globigerinidae, Hastigerinidae, Globorotaliidae, and Candeinidae, using active chlorophyll fluorometry (fast repetition rate fluorometry; FRRF). FRRF performs non-destructive and non-invasive measurements of algal physiology based on real-time variable fluorescence profiles. When it is applied to symbiotic consortia of planktic foraminifers, it enables us to quantify chlorophyll content of a specimen, and to qualify of photophysiological features that are useful diagnostics of symbiont photosynthetic fitness. It can provide us with convincing information on individual-based photosymbiosis.
Specimens were collected from various oceanic settings; from tropical to subpolar region, encompassing Pacific to Atlantic. We have sampled across much of the northern hemisphere tropical-subtropical gradient to get the endemic species and to replicate for the others. The detection rate of photosymbiosis in each species, the biomass of symbionts (indicated by chlorophyll content), and the state of symbionts (indicated by photophysiological parameters) were investigated. Using principal component analysis, species were ranked by their “strength” of photosymbiosis. This thorough investigation will provide a more systematic understanding of photosymbiosis in modern planktic foraminifers and will help us to choose which species to use to reconstruct paleoenvironment.

Keywords: planktic foraminifers, photosymbiosis

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Evaluation of geochemistry in hypercalcified demosponges as a paleoceanographic proxy

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Hypercalcified sponges (hereafter, “sclerosponges”), living in dark environments of tropical to subtropical shallow oceans, precipitate calcium carbonate skeleton with growth bands. They grow slowly at an approximate rate of <1 mm/year unlike corals (ca. 1 cm/year) but can be so long-lived for several decades to hundred years like corals (e.g., Benavides and Druffel, 1986 Coral Reefs). Skeletal oxygen isotopic ratios in sclerosponges can reflect variations in sea surface temperature and seawater with the latter being potentially related to salinity reflecting the precipitation–evaporation balance at the sea surface and changes in water mass transport (e.g., Grottoli et al., 2010 J. Geophys. Res.). In contrast to zooxanthellate corals, which occasionally show positive correlations between skeletal oxygen and carbon isotopic ratios, it is considered that there do not exist vital effects in the secretion of sclerosponge skeleton. Previous studies showed significant decrease trends in the carbon isotope records toward the present, which is probably a result of isotopically-light carbon dioxide added into the atmosphere/ocean from fossil fuel burning (e.g., Swart et al., 2010 Geophys. Res. Lett.). Therefore, sclerosponges are shown to provide annually resolved time series of proxy records of ocean environments since the Industrial Revolution. However, few evaluation studies on the environmental proxy of sclerosponges are reported, and temporally longer (>100 year-continuous-long) records from sclerosponges were derived only from the Atlantic Ocean.

Here we present stable oxygen and carbon isotope ratios and trace elements (Mg, Ca, Sr, Ba, Pb and U) from sclerosponges (*Astrosclera willeyana* and *Acanthochaetetes wellsi*) collected from Kume-jima, Okinawa-jima and Miyako-jima, Ryukyu Islands in the North Pacific. In order to evaluate the utility of sclerosponge as an environmental proxy, within-skeleton and intraspecific variations in stable isotopic and trace elemental records of 37 samples were investigated. Soft X-ray images of large-size sclerosponges showed highly developed skeletal growth bands with >100 high/low density layers. The secular changes in radiocarbon-dated time series of the sclerosponge carbon records were consistent with previously reported data from Atlantic and Pacific corals and sclerosponges. The long-term oxygen isotopic trends of the samples are characterized by slight depletions throughout their living periods, indicative of an overall trend toward warmer ocean environment around the Ryukyu Islands. Our sclerosponge-based estimates of sea surface temperature and salinity may document thermal and hydrologic variations in the Ryukyu Islands, furthering a better understanding of northwestern tropical-subtropical Pacific climate change for the last several centuries in conjunction with coral-based long proxy records.

Keywords: sclerosponge, oxygen isotope, carbon isotope, trace element, paleoceanogrpahy, Okinawa

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[E] Poster | B (Biogeosciences)：B-PT Paleontology

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_36

[B-PT04] Biomineralization and the Geochemistry of Proxies

convener:Takashi Toyofuku(Japan Agency for Marine-Earth Science and Technology (JAMSTEC)), Hiroshi Kitazato(Tokyo University of Marine Science and Technology (TUMSAT)), Jelle Bijma(Alfred-Wegener-Institut Helmholtz-Zentrum f?r Polar- und Meeresforschung), Kotaro Hirose(Faculty of Science & Engineering, Waseda University)

Biomineralization and the Geochemistry of Proxies - Biology, laboratory culture-experiments and their applications to the paleo-research -
In order to reconstruct the Earth climate system, marine paleoclimatologists resort to transfer functions or geochemical proxies, which are produced or affected by organisms. The relationships used for reconstructions are generally based on field calibrations or derived from laboratory experiments. The danger of these so-called empirical relationships is that they may be valid only within the restricted parameter space of their calibration. Application of proxy relationships to very different environmental settings (e.g. high vs. low latitude or glacial vs. interglacial) requires a mechanistic understanding of these relationships. Much progress can be expected by a better understanding of the biomineralization mechanisms and the incorporation of proxy signals.
In this session we facilitate contributions related to the biomineralization, calibration and validation of marine proxies from field study, laboratory culture experiment and paleo-environmental reconstruction.

[BPT04-P01] Living (stained) benthic foraminifera in the West-Gironde mud patch (Bay of Biscay, France): An ongoing survey for the European Community.

*Christophe Fontanier[1,2], Bruno Deflandre[1], Sylvain Rigaud[3], Sabine Schmidt[1], Bastien Lamarque[1], Pascal Lebleu[1], Dominique Poirier[1], Antoine Grémare[1] (1. Bordeaux University, EPOC Laboratory, UMR CNRS 5805 OASU, F-33615 Pessac, FRANCE, 2.FORAM Research Group, F-49140 Villevêque, FRANCE, 3.Nîmes University, GIS Laboratory, EA 7352 CHROME, F-30035 Nïmes, FRANCE)

[BPT04-P02] Biomonitoring in the Cassidaigne Canyon (NW Mediterranean): the resilience and recovery of deep-sea benthic foraminifera at a bauxite industrial waste site

*Pauline Duros[1], Christophe Fontanier[1,2,3], Briony Mamo[4,5], Deborah Mille[6], Olivier Herlory[6] (1.FORAM Research Group, F-49140 Villevêque, FRANCE, 2.Bordeaux University, EPOC Laboratory, UMR CNRS 5805 OASU, F-33615 Pessac, FRANCE, 3.Angers University, 4 boulevard Lavoisier, F-49000 Angers, FRANCE., 4.School of Biological Sciences, University of Hong Kong, Pokfulam Road Sai Wan, Hong Kong SAR, CHINA. , 5.Department of Biology, Macquarie University, North Ryde, NSW, 2109, AUSTRALIA., 6.CREOCEAN, Agence PACA Corse, 230 Avenue de Rome, Valparc-Bât B, F-83500 La Seyne sur Mer, FRANCE.)

[BPT04-P03] Comparison between assemblages of diatom fossil and biomarkers in surface sediments from Seto Inland Sea

*Kotaro Hirose[1], Hideto Nakamura[2], Takuto Ando[4], Satoshi Asaoka[3], Ken Sawada[5] (1.Faculty of Science & Engineering, Waseda University, 2.Faculty of Science, Osaka City University, 3.Research Center for Inland Seas & Department of Planetology, Kobe University, 4.Arctic Research Center, Hokkaido University, 5.Department of Earth & Planetary Science, Faculty of Science, Hokkaido University)

[BPT04-P04] Combined impacts of ocean acidification and desalination: culture experiments on the coastal species *Ammonia* sp. and *Elphidium crispum*

*Laurie Marie Charrieau[1], Helena L. Filipsson[2], Yukiko Nagai[1], Sachiko Kawada[1], Karl Ljung[2], Emma Kritzberg[3], Takashi Toyofuku[1,4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Department of Geology, Lund University, Sweden, 3.Department of Biology, Lund University, Sweden, 4.Tokyo University of Marine Science and Technology (TUMSAT), Japan)

[BPT04-P05] Effects on larger benthic foraminiferal shell density under global warming

*Shunichi Kinoshita[1], Azumi Kuroyanagi[2], Hiroshi Nishi[2], Osamu Sasaki[2], Kazuhiko Fujita[3], Atsushi Suzuki[4], Hodaka Kawahata[5] (1.Graduate School of Science, Tohoku University, 2.The Tohoku University Museum, The Center for Academic Resources and Archives, Tohoku Univerity, 3.Department of Physics and Earth Sciences, Faculty of Science and Tropical Biosphere Research Center, University of the Ryukyus, 4.Geological Survey of Japan National Institute of Advanced Industrial Science and Technology, 5.Atmosphere and Ocean Research Institute, the University of Tokyo)

[BPT04-P06] Estimation of the calcification rate of foraminifera -exceptionally fast extending of the shell-

*Yukiko Nagai[1,2], Katsuyuki Uematsu[3], Takashi Toyofuku[2,4] (1.National Museum of Nature and Science of Tokyo, 2.Japan Agency for Marine-Earth Science and Technology, 3.Marine Works Japan Enterprise, 4.Tokyo university of Marine Science and Technology)

[BPT04-P07] Estimation of foraminiferal calcification process from live imaging and FIB-SEM approach

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[BPT04-P08] Toward a better understanding of planktic foraminiferal proxies: Are they photosymbiotic or not?

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[BPT04-P09] Evaluation of geochemistry in hypercalcified demosponges as a paleoceanographic proxy

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Living (stained) benthic foraminifera in the West-Gironde mud patch (Bay of Biscay, France): An ongoing survey for the European Community.

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During an environmental survey performed in summer 2017 (JERICObent-2 Cruise), living (stained) benthic foraminiferal faunas were investigated at 7 stations sampled within the West-Gironde mud patch, a mud belt located on the marine shelf in front of the Gironde River (Bay of Biscay, France). This study area is really strategic for local fisheries since substantial marine resources (demersal fishes, shrimps...) are easily accessible for coastal fishermen. Moreover, the mud belt is considered an important hotspot for marine biodiversity as far as food (i.e. sedimentary organic matter), which is naturally abundant there, could sustain an assumedly enhanced heterogeneity of benthic habitats for various taxon. In the framework of the European project JERICONext (ID 654410), we have been studying biological (prokaryotes, benthic meiofauna and macrofauna), sedimentary and geochemical patterns of mud-flat ecosystems in order to better understand how both spatial and temporal variability of riverine regime and coastal hydrodynamics impact the dynamics of the benthic life, especially foraminifera. Stations investigated in this presentation are located between 39 and 69 m water depth from the inner shelf to the mid-shelf. At most sites, surface sediment is characterized by clay-silt facies more or less enriched in organic matter. Oxygen penetration depth within the sediment is less than 7±3 mm. Foraminiferal simple diversity (S) presents relatively moderate values ranging between 15 and 35 taxa. According to Shannon Index H' and Rarefaction Index ES(100), foraminiferal diversity tends to slightly increase with water depth. This trend is supported by *Eggerelloides scabrus;* its contribution decreases from the shallower stations (~50%) of the proximal mud patch (<55 m depth) to the deeper stations (<30%) of the distal mud patch (>55 m depth). This agglutinated species is generally considered a reliable bio-indicator of organic-matter enriched sediment in front of river mouths. It is noteworthy that the shallowest station (station 1, 39 m) is also characterised by the exclusive contribution of *Quinqueloculina lata/laevigata* and *Ammonia beccarii,* which are both typical of inner-shelf environments. There, surface sediment is made of fine sand. The deeper stations (>55 m depth) located in the distal mud patch are characterised by a remarkable contribution (~30%) of *Pseudoeponides falsobeccarii* and Buliminids (~30% respectively). They are accompanied by *Rectuvigerina phlegeri* and *Nonion fabum*, which are typical of mid- and outer-shelf ecosystems. The contribution of Buliminids underline the gradual increase of sedimentary organic content (>1.2% DW) with water depth.

Keywords: Living Benthic Foraminifera, Mud Belt, Environmental Spatial Variability, Sedimentary Organic Matter, Oxygenation Level

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Biomonitoring in the Cassidaigne Canyon (NW Mediterranean): the resilience and recovery of deep-sea benthic foraminifera at a bauxite industrial waste site

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During an environmental survey performed in autumn 2016, living (stained) benthic foraminiferal faunas were investigated at 16 stations sampled within the Cassidaigne Canyon (NW Mediterranean Sea) and surrounding area. For many decades, industrial bauxite residues of red mud have drained into the canyon via a submarine pipe, causing physical disturbance and chemical contamination. In January 2016, solid waste disposal ceased and was replaced with the dumping of a low-density liquid effluent. Stations investigated in this paper are located between 265–2500 m water depth from the shelf break to the deeper basin and from a distance between 4–70 km from the pipe outlet. At many sites, surface sediment is characterized by historical deposits of red mud and their geochemical imprints. Our ecological observations at the 725 m-depth station closest to the Cassidaigne Canyon submarine pipe show the highest concentration of the opportunistic and stress-tolerant species *Bulimina marginata* d' Orbigny, 1826, commonly identified as a recolonizer of disturbed areas. At the other fifteen stations, foraminiferal standing stocks and simple diversity (S) decrease with decreasing food input to the seafloor and increasing water depth. There, foraminiferal composition is characterized by a minor contribution of stress-tolerant species and echoes the overall meso-oligotrophic patterns of a relatively stable ecosystem. Our study clearly shows that in September 2016, 10 months after a historical shift in discharged industrial wastes (from dense red mud to liquid effluent), foraminiferal diversity close to the pipe outlet in the Cassidaigne Canyon remains altered, but appears to be slowly recovering.

Keywords: Benthic foraminifera, Bauxite residues, Cassidaigne Canyon, Resilience

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Comparison between assemblages of diatom fossil and biomarkers in surface sediments from Seto Inland Sea

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We investigate the fossil diatom abundances and biomarker concentrations in marine sediment to assess their relationships. 14 sample of surface (uppermost 5 cm of sea bottom) sediments are taken in 5 areas (Aki-nada Bay, Hiuchi-nada Bay, Harimanada-Bay, Osaka Bay and Kii Strait) of Seto Inland Seas in July 2015. Additional 8 samples are taken in Harimanada-Bay in October 2015. Although the precise age of the core has not been determined yet, it could be deposited within 10 years, according to the sedimentation rates by previous study (Yasuhara et al., 2007).
Diatom species such as small *Thalassiosira*spp., *skeletonema costatum*, resting spore of *Chaetoceros* spp. and *Neodelphyneis pelagica*, which were reported by previous study (Hirose et al., 2008), are observed as the dominant taxa in all samples. *Rhizosolenia* spp. and *Pleurosigma* spp., known HBI producers, were occurred in low proportions. As specific diatom biomarkers, we identified C25 di- and tri-unsaturated highly branched isoprenoids (HBIs), along with relatively minor amount of C25 and C35 cyclic HBIs. Total abundances of diatom valves and HBIs were generally correlated, probably reflecting variations of diatom production. Meanwhile, Aki-bay and some samples of Harima-nada Bay were characterized with relatively low abundance of HBIs relative to valves. In these area, focused analysis on the minor diatom taxa would be needed to provide quantitative dataset to discuss further relation of HBIs and produces and their spatial distribution.

Keywords: diatom assemblage, diatom biomarkers, HBIs, surface sediment, Seto Inland Seas

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Combined impacts of ocean acidification and desalination: culture experiments on the coastal species *Ammonia* sp. and *Elphidium crispum*

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Coastal areas display natural large environmental variability such as frequent changes in salinity, pH, and carbonate chemistry. Anthropogenic impacts –especially ocean acidification –increase this variability, which may affect the living conditions of coastal species, particularly, calcifiers, such as foraminifera.

The purpose of this study was to evaluate the combined effect of two typical environmental stressors on the coast - salinity and pH –on calcifying organisms. We performed culture experiments on living benthic foraminifera to study the combined effects of lowered pH and salinity on the calcification abilities and survival of the coastal, calcitic species Ammonia sp. and *Elphidium crispum*.

We found that these two species could tolerate low pH and low salinity, which reflects the environmental variations in their natural habitats. However, in open ocean conditions (salinity ~35) and lower pH treatment, the species displayed resistance to test dissolution for a longer time than in brackish conditions (salinity ~5 to 20). Moreover, the response of foraminifera to the different treatments was species-specific, and *Ammonia* sp. appeared more resistant than *E. crispum* when placed in the same conditions of pH and salinity. We also observed living dissolved specimens of juveniles *Ammonia* sp. under the combined effect of low pH and very low salinity, and we showed that desalination is one cause for the decalcification. However, they were not able to recalcify when returned to higher salinities, probably due to a sensitive balance in environmental parameters. Finally, we highlight the ability of foraminifera to survive under $\Omega calc < 1$, and that high salinity and $[Ca^{2+}]$ as building blocks are crucial for the foraminiferal calcification process.

We conclude that coastal benthic foraminifera will not immediately be affected by ocean acidification, but rather by a combination of decreasing salinity and lowered pH.

Keywords: Coastal ocean acidification, Desalination, Culture experiment, Benthic foraminifera, Calcification process

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Effects on larger benthic foraminiferal shell density under global warming

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On the recent ocean environment, due to progresses of global warming and ocean acidification, it is concerned that calcifying organisms will be seriously affected from these environmental changes. Larger benthic foraminifers (LBFs) build calcium carbonate shells. Their carbonate productivity is the third highest rate in coral reef area next to reef corals and calcareous algae. Therefore, it is important to clarify the relationship between ocean environmental changes and the response of LBFs for predicting future ocean environment including carbon cycle. Based upon test diameter and shell weight, previous studies expected how foraminifers react to sea water conditions where they are living. However, in those reports, it is still not clear whether the changing of shell weight is due to changing of shell thickness (shell volume) or shell density, also whether that changing is depending sea water temperature or acidity. Thus, this study was performed for clarifying the relationships between water temperature and LBFs shell parameters with laboratory experiments and means of micro computed tomography (CT).

In this study, we cultured the LBF *Sorites orbiculus* in filtered sea water until reproduction. Soon after *S. orbiculus* reproduced, clonal individuals from same mother individual were picked and separated into seven groups. One group was selected as initial stage sample, and other six groups were provided for culture experiments. We cultured each groups under six different temperature conditions (19, 21, 23, 25, 27 and 29 ˚C). Because clonal specimens were reproduced asexually from same individual, it was expected the genetic factors were kept to a minimum. We used micro CT to investigate mean CT number (proxy of density), shell volume, test diameter and chamber number of every clonal specimen after culturing. The results show the high correlation of mean CT number with temperature in contrast to the correlation of shell volume and temperature. This suggests changing in temperature of sea water causes shell density difference, furthermore, LBFs build the higher density shell in the higher temperature as long as they lives in 19 to 29 C˚ environment.

Keywords: Larger benthic foraminifer, shell density, micro CT, laboratory experiments, global warming

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Estimation of the calcification rate of foraminifera -exceptionally fast extending of the shell-

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The process of biomineralization of foraminiferal test is essential for its characteristic morphogenesis and the composition of element and isotope to be taken in is used also as paleo environmental proxy, numerous studies have been approched to reveal the mechanism of shell formation. However, how fast the foraminifera calicification and how much calcium carbonate deposits depends on the species, which is not well understood in most species.
The foraminifera *Spirillina vivipara* does not form a chamber, but elongate a tubular test spirally with their cytoplasmic growth. *Spirillina vivipara* is also known to be rapidly changing generations that can be reproduced in a several days after division of mother cells (Myers, 1936). From our current observations, it was also found that the shell formation is repeatedly carried out in the day, and the elongation rate of the shell is very fast. Therefore, in this study, Spirillina vivipara was used to estimate calcification rate.
In this presentation, we report on the fastest shell extending rate in foraminifera.

Keywords: Calcification, foraminifera, FIB-SEM

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Estimation of foraminiferal calcification process from live imaging and FIB-SEM approach

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Calcareous foraminifera have been thought a major carbonate producer in ocean. Their tests (shells) are fundamental tools as paleo-environmental indicators in various studies because their calcareous tests have been archived as numerous fossils in sediment for geologic time and various environmental information are brought by faunal structure, shell morphology and geochemical compsitions of calccitic test. The other hand, the calcification process itself is interested for us. Pseudopodia sticking out into sea water build organic templates in the form of chamber. Calcium carbonate is precipitated on the both side of template within several hours. Calcium and carbonate are fixed at there by foraminiferal biological process. The newly added chamber wall was flexible in a first day, the chamber solidified in a few days and became a solid test. It is very interesting to record this process in video. Our studies showed the variable change of pH and Ca during the biomineralization of foraminifera by the application of fluorescent indicators (e.g. Toyofuku et al., 2017). Recently, we also apply the method to clear cut the site of calcification under SEM by focused ion beam (FIB-SEM)(Nagai et al., 2018). The nano-scale fine structures have been revealed the distribution of soft orgnic structures (i.e. pseudopodia) and hard tissue (precipitated calium carbonate)by this observation.

Keywords: calcification, foraminifera, imaging

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Toward a better understanding of planktic foraminiferal proxies: Are they photosymbiotic or not?

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Geochemistry of planktic foraminiferal tests is an important archive to understand paleoenvironment. However, many biotic factors can affect the geochemical composition and thus may lead misinterpretation of the proxy signals. Photosymbiosis (endosymbiosis with autotrophic algae) is thought to give specific effects on foraminiferal test geochemistry such as $\delta^{13}C$ due to photosynthetic activity of the symbionts. This is because photosynthesis can alter the geochemical condition of the vicinity of the foraminiferal test where calcification takes place, and eventually elevate the $\delta^{13}C$ of the test. Therefore, whether foraminiferal species have photosymbiotic ecology or not, and how active the photosynthesis is are important information for precise paleoenvironmental reconstructions. However, photosymbiotic information of planktic foraminifers is still limited even for extant species which are often utilized to generate proxy records.
In this study, we investigated 30 species of modern planktic foraminifers covering four families; Globigerinidae, Hastigerinidae, Globorotaliidae, and Candeinidae, using active chlorophyll fluorometry (fast repetition rate fluorometry; FRRF). FRRF performs non-destructive and non-invasive measurements of algal physiology based on real-time variable fluorescence profiles. When it is applied to symbiotic consortia of planktic foraminifers, it enables us to quantify chlorophyll content of a specimen, and to qualify of photophysiological features that are useful diagnostics of symbiont photosynthetic fitness. It can provide us with convincing information on individual-based photosymbiosis.
Specimens were collected from various oceanic settings; from tropical to subpolar region, encompassing Pacific to Atlantic. We have sampled across much of the northern hemisphere tropical-subtropical gradient to get the endemic species and to replicate for the others. The detection rate of photosymbiosis in each species, the biomass of symbionts (indicated by chlorophyll content), and the state of symbionts (indicated by photophysiological parameters) were investigated. Using principal component analysis, species were ranked by their “strength” of photosymbiosis. This thorough investigation will provide a more systematic understanding of photosymbiosis in modern planktic foraminifers and will help us to choose which species to use to reconstruct paleoenvironment.

Keywords: planktic foraminifers, photosymbiosis

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Evaluation of geochemistry in hypercalcified demosponges as a paleoceanographic proxy

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Hypercalcified sponges (hereafter, “sclerosponges”), living in dark environments of tropical to subtropical shallow oceans, precipitate calcium carbonate skeleton with growth bands. They grow slowly at an approximate rate of <1 mm/year unlike corals (ca. 1 cm/year) but can be so long-lived for several decades to hundred years like corals (e.g., Benavides and Druffel, 1986 Coral Reefs). Skeletal oxygen isotopic ratios in sclerosponges can reflect variations in sea surface temperature and seawater with the latter being potentially related to salinity reflecting the precipitation–evaporation balance at the sea surface and changes in water mass transport (e.g., Grottoli et al., 2010 J. Geophys. Res.). In contrast to zooxanthellate corals, which occasionally show positive correlations between skeletal oxygen and carbon isotopic ratios, it is considered that there do not exist vital effects in the secretion of sclerosponge skeleton. Previous studies showed significant decrease trends in the carbon isotope records toward the present, which is probably a result of isotopically-light carbon dioxide added into the atmosphere/ocean from fossil fuel burning (e.g., Swart et al., 2010 Geophys. Res. Lett.). Therefore, sclerosponges are shown to provide annually resolved time series of proxy records of ocean environments since the Industrial Revolution. However, few evaluation studies on the environmental proxy of sclerosponges are reported, and temporally longer (>100 year-continuous-long) records from sclerosponges were derived only from the Atlantic Ocean.

Here we present stable oxygen and carbon isotope ratios and trace elements (Mg, Ca, Sr, Ba, Pb and U) from sclerosponges (*Astrosclera willeyana* and *Acanthochaetetes wellsi*) collected from Kume-jima, Okinawa-jima and Miyako-jima, Ryukyu Islands in the North Pacific. In order to evaluate the utility of sclerosponge as an environmental proxy, within-skeleton and intraspecific variations in stable isotopic and trace elemental records of 37 samples were investigated. Soft X-ray images of large-size sclerosponges showed highly developed skeletal growth bands with >100 high/low density layers. The secular changes in radiocarbon-dated time series of the sclerosponge carbon records were consistent with previously reported data from Atlantic and Pacific corals and sclerosponges. The long-term oxygen isotopic trends of the samples are characterized by slight depletions throughout their living periods, indicative of an overall trend toward warmer ocean environment around the Ryukyu Islands. Our sclerosponge-based estimates of sea surface temperature and salinity may document thermal and hydrologic variations in the Ryukyu Islands, furthering a better understanding of northwestern tropical-subtropical Pacific climate change for the last several centuries in conjunction with coral-based long proxy records.

Keywords: sclerosponge, oxygen isotope, carbon isotope, trace element, paleoceanogrpahy, Okinawa

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[J] Oral | G (General)：General

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 104 1F

[G-01] Disaster prevention education

convener:Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education), Jiro Komori(Teikyo Heisei University), Shintaro Hayashi(Akita University Graduate School of Education), Chairperson:Jiro Komori(Teikyo Heisei University)

Each time a serious disaster occurs, there are calls for better disaster prevention education in and around the stricken area, and such education is actually implemented. However, it is not extended to other parts of the nation. Although disaster prevention education really is needed across Japan, it tends to be implemented only in the directly affected locality of a catastrophic disaster. Moreover, even in affected areas, when 10 to 20 years have elapsed from a major event, with a decline in the number of survivors, there is less motivation to pass experiences and learning on to the next generation, despite the potential for such disasters to recur, tens or hundreds of years into the future. It is not easy to maintain conversations about disaster experiences through several generations. Consequently, effective disaster prevention education is provided only in the region stricken by a particular event, and it is practiced only for up to 20 years following the last disaster. As a result, provision of disaster prevention education has become less effective in many areas of Japan. This session focuses on the following two questions: (1) What kind of disaster prevention education can be practiced continuously nationwide? (2) How can such disaster prevention education be implemented in schools and educational sessions? We encourage anyone who wishes to help develop new disaster prevention education based on awareness of these issues to make a presentation in this session. Participation is not restricted to geoscientists; any person or group engaged in any domain of disaster prevention is welcome to submit a paper.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[G01-01] New high school compulsory subjects"Chiri-sougou(Comprehensive geography)"! : Possibility to promote disaster education

*Shintaro Hayashi[1] (1.Akita University Graduate School of Education)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[G01-02] Kyushu University's multidisciplinary disaster prevention education for students near nuclear power plants after 2016 Kumamoto earthquake

*Megumi Sugimoto[1,2], Silvia Peppoloni[2] (1.Kyushu University, 2.International Association for Promoting Geoethics)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[G01-03] The cases of the limit of dam impoundment during floods and necessity of information sharing at local disaster prevention

*Jiro Komori[1], Yuuri Masuhara[1] (1.Teikyo Heisei University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[G01-04] Disaster Tradition and Disaster Education of 2008 Sichuan Earthquake

★Invited Papers

*FU SIQI[1], Shiroshita Hideyuki[1] (1.Kansai University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[G01-05] Preparedness for Nankai Trough Earthquake: Incorporating Understandings of Uncertainties in Disaster Prevention Education Schemes

*Manabu Hashimoto[1], Mika Shimizu[2] (1.Disaster Prevention Research Institute, Kyoto University, 2.Center for the Promotion of Interdisciplinary Education and Research, Kyoto University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[G01-06] Importance of issuing evacuation for individual family
★Invited Papers

*Suzuki Shigeyuki[1] (1.Okayama University)

New high school compulsory subjects"Chiri-sougou(Comprehensive geography)"! : Possibility to promote disaster education

*Shintaro Hayashi[1]

1. Akita University Graduate School of Education

A new subject "Comprehensive geography(Chiri-sougou)" is implemented in high school from 2022. "Comprehensive geography" may be a powerful tailwind for promotion of disaster education education. Because
1) "Comprehensive geography" is a compulsory course to be taken by most high school students.
2) Learning about disasters is a big part.

Disaster-related officials, such as related organizations and departments of the country and the prefecture, researchers involved in disaster prevention education, NPO corporations, Geopark, etc., need to make sufficient preparations, such as contacting the high school side and discussing. If you do so, there is a possibility that you can greatly contribute to the dissemination of disaster prevention education by taking advantage of this new subject.
"Comprehensive geography" is a compulsory subject: High school "Geography comprehensive" is a compulsory subject to be implemented from 2022. It is indicated in the curriculum guidelines published by the Ministry of Education, Culture, Sports, Science and Technology in 2018, and the textbook preparation work is ongoing. Almost all high school students will be taking classes from 2022.
Since the 1970's, geography subjects have been taken as non-compulsory courses. The revision of this time has resulted in a great increase in the weight of geography subjects.
Learning about disasters is the main contents of "Comprehensive geography": contents of "Comprehensive geography" can be roughly divided into three - "contemporary world thought in maps and geographical information systems" "international understanding and international cooperation" "sustainable regional creation ".
"Sustainable community development" is further divided into "natural environment and disaster prevention", "research on living area and regional perspective". "Natural environment and disaster prevention" is to acquire knowledge about preparation and response to natural disasters, to undertake task exploration activities, and to acquire skills to read hazard maps and topographic maps.
However, the high school does not have enough resources to conduct the lesson of the natural disaster part of the new subject "Comprehensive geography". In high school there is a shortage of teaching materials and lessons for compulsory conversion of "Comprehensive geography". Educational materials necessary for implementation of "Comprehensive geography" are knowledge of various disasters, knowledge about disasters in the area, learning materials such as hazard maps, and so on. In addition, disaster prevention personnel can also be involved in "Comprehensive geography" as a lesson. Both materials can be provided to the high school side by disaster prevention related institutions.
Teaching Materials Required for "Comprehensive geography" Implementation: "Comprehensive geography"requires two kinds of teaching materials.
1) Materials concerning disasters in the region: Natural disasters occurred in the area in the past and materials on preparation for disaster are necessary. Materials on historical disasters are particularly important. Also, hazard maps and topographic maps are essential learning materials. Also, in "comprehensive geography", high school students will learn about either earthquakes, tsunami, weather disasters, or volcanic disasters.
2) Exploratory learning on disasters is based on "Regarding disaster prevention based on regional

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characteristics, pay attention to relationships with nature and social conditions, common points and differences in areas, creating a sustainable community, It is multifaceted and multilateral consideration and expression for preparation and response to natural disasters (literal translation) ". Disaster prevention related organizations can provide materials for exploration. Disaster prevention related institutions themselves are also materials of explorative learning.
In this way, the new subject "Comprehensive geography" opened in high school from 2022 is highly likely to be a powerful tailwind for promoting disaster education education, People involved in disaster prevention need to participate in "comprehensive geography" classes.

Keywords: Comprehensive geography, Disaster education, Curriculum guidelines published by the Ministry of Education, Culture, Sports, Science and Technology in 2018

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Kyushu University's multidisciplinary disaster prevention education for students near nuclear power plants after 2016 Kumamoto earthquake

*Megumi Sugimoto[1,2], Silvia Peppoloni[2]

1. Kyushu University, 2. International Association for Promoting Geoethics

Kyushu University start disaster prevention education program 2017 Kumamoto earthquake. This multidisciplinary disaster prevention education program me was requested to professors by students after the 2016 Kumamoto earthquake. Kyushu University is located at 32 km from Nuclear power plant Genkai has restarted already. Medical doctors, oceanographers, meteorologists, seismologists, volcanologists, hydologists natural hazard management specialists, artists and designers join this program too. We would like to introduce this program in our presentation.

Keywords: Risk mangement, Urgent Protective action planning Zone, Geoethics, specialization, Disaster prevention education for students, evacuation from nuclear accidents

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The cases of the limit of dam impoundment during floods and necessity of information sharing at local disaster prevention

*Jiro Komori[1], Yuuri Masuhara[1]

1. Teikyo Heisei University

Two major flood of the 2018 Japan floods (heavy rain and flood disaster in the western Japan), Takahashi River in Okayama and Hiji River in Ehime had emergency discharge from managed dams in upper streams. The interpretation, especially the decision of success or failure of dam management is difficult. However, there are some concerns of local residents, and the fact of worsening of terms of natural condition due to global warning and sand accumulation in dam lakes.
Thus, we listed the similar cases of the 2018 floods, which occurred with emergency discharge at the upstream from a dam. Total 65 cases are compiled from web databases for the previous 60 years newspaper articles in Yomiuri, Asahi and Mainichi (Japanese 3 major dailies). The list shows recurrence cases of flood with discharge from same dam and tendency of “the limit of dam” of decrepit structure. While, educational effect are appear by information sharing between dam management and residents.

Keywords: 2018 Japan floods, dam management, emergency discharge, artificial calamity, information sharing, case study

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洪水した河川の上流でダムの緊急放流があった事例

ver.20190118

	発生年	ダム名	河川名	所在地	建設着工/完成年	降雨の原因
1	1958年8月1日	殿山ダム	日置川	和歌山県田辺市	1955/1957	台風17号
2	1961年6月28日	美和ダム	三峰川	長野県伊那市	1952/1959	梅雨前線
3	1962年7月27日	風屋ダム	十津川	奈良県吉野郡十津川村	1954/1960	台風7号
4	1962年7月27日	二津野ダム	十津川	奈良県吉野郡十津川村	1959/1962	台風7号
5	1962年7月27日	殿山ダム	日置川	和歌山県田辺市	1955/1957	台風7号
6	1962年8月26日	相模ダム	相模川	神奈川県相模原市	1937/1947	台風14号
7	1965年7月1日	市房ダム	球磨川	熊本県球磨郡水上村	1953/1959	梅雨前線
8	1965年9月17日	佐久間ダム	天竜川	静岡県浜松市	1954/1958	台風24号
9	1965年9月17日	秋葉ダム	天竜川	静岡県浜松市	1953/1956	
10	1971年8月1日	長安口ダム	那賀川	徳島県那賀郡那賀町	1950/1955	台風23号
11	1972年7月6日	鶴田ダム	川内川	鹿児島県薩摩郡さつま町	1959/1965	梅雨前線
12	1972年7月11日	新成羽川ダム	成羽川	岡山県高梁市	? /1968	梅雨前線
13	1972年7月12日	立岩ダム	太田川	広島県広島市	? /1939	
14	1975年8月17日	早明浦ダム	吉野川	高知県長岡郡本山町	1965/1978	台風5号
15	1981年8月5日	大夕張ダム	夕張川	北海道夕張市	1954/1961	台風12号
16	1982年8月1日	大迫ダム	吉野川	奈良県吉野郡川上村	1954/1973	台風10号
17	1990年9月19日	永源寺ダム	愛知川	滋賀県東近江市	1952/1972	台風19号
18	1990年9月19日	殿山ダム	日置川	和歌山県田辺市	1955/1957	
19	1994年9月22日	樽水ダム	増田川	宮城県名取市	1965/1976	寒冷低気圧
20	1994年9月22日	釜房ダム	名取川	宮城県柴田郡川崎町	1964/1970	
21	1994年9月23日	七北田ダム	七北田川	宮城県仙台市	1972/1984	
22	1994年9月23日	大倉ダム	大倉川	宮城県仙台市	1956/1961	
23	1995年7月1日	裾花ダム	裾花川	長野県長野市	1962/1969	梅雨前線
24	1995年7月1日	鹿野川ダム	肱川	愛媛県大洲市・西予市	1953/1958	梅雨前線
25	1997年7月26日	殿山ダム	日置川	和歌山県田辺市	1955/1957	台風9号
26	1997年9月16日	北川ダム	北川	大分県佐伯市	1958/1962	台風19号
27	1998年10月17日	旭川ダム	旭川	岡山県岡山市	1949/1954	台風10号
28	1999年9月15日	鹿森ダム	足谷川	愛媛県新居浜市	1958/1962	台風16号/秋雨前線
29	1999年8月14日	玄倉ダム	玄倉川	神奈川県上足柄郡山北町	1957/1958	熱帯低気圧
30	2000年9月12日	矢作ダム	矢作川	愛知県豊田市	1962/1970	台風14号/秋雨前線
31	2001年8月21日	七川ダム	古座川	和歌山県東牟婁郡古座川町	1951/1956	台風11号
32	2001年8月21日	小匠ダム	小匠川	和歌山県東牟婁郡那智勝浦町	? /1959	台風11号
33	2003年8月9日	二風谷ダム	沙流川	北海道沙流群平取町	1973/1997	台風10号と前線
34	2004年7月13日	刈谷田川ダム	刈谷田川	新潟県長岡市	1968/1980	梅雨前線
35	2004年7月13日	笠堀ダム	笠堀川	新潟県三条市	1959/1964	
36	2004年7月13日	大谷ダム	五十嵐川	新潟県三条市	1971/1993	
37	2004年8月30日	鹿野川ダム	肱川	愛媛県大洲市・西予市	1953/1958	台風16号
38	2004年8月30日	池田ダム	吉野川	徳島県三好市	1968/1974	台風16号
39	2004年9月29日	宮川ダム	宮川	三重県大台町	1951/1956	台風21号
40	2004年9月30日	萩形ダム	小阿仁川	秋田県北秋田郡上小阿仁村	1961/1966	
41	2004年10月20日	鮎屋川ダム	鮎屋川	兵庫県洲本市鮎屋	? /1970	台風23号
42	2004年10月20日	前山ダム	鴨部川	香川県さぬき市	1968/1974	
43	2004年10月20日	大川ダム	津田川	香川県さぬき市	1959/1963	
44	2004年10月20日	五名ダム	湊川	香川県東かがわ市	1952/1962	
45	2005年9月6日	菅野ダム	錦川	山口県周南市・岩国市	1959/1965	台風14号
46	2005年9月6日	温井ダム	滝山川	広島県山県郡安芸太田町	1974/2001	
47	2005年9月6日	鹿野川ダム	肱川	愛媛県大洲市	1953/1958	
48	2006年7月22日	鶴田ダム	川内川	鹿児島県薩摩郡さつま町	1959/1965	梅雨前線
49	2006年8月16日	三保ダム	酒匂川	神奈川県足柄上郡山北町	1969/1978	台風10号
50	2007年9月17日	森吉ダム	小又川	秋田県北秋田市	1951/1952	温帯低気圧（台風11号）
51	2010年7月15日	木屋川ダム	木屋川	山口県下関市	1940/1955	梅雨前線
52	2011年7月29日	本名ダム	只見川	福島県大沼郡金山町	1952/1954	梅雨前線
53	2011年7月30日	笠堀ダム	笠堀川	新潟県三条市	1959/1964	
54	2011年7月30日	大谷ダム	五十嵐川	新潟県三条市	1971/1993	
55	2011年9月4日	七色ダム	北山川	三重県熊野市	1963/1965	台風12号
56	2011年9月4日	七川ダム	古座川町	和歌山県東牟婁郡古座川町	1951/1956	
57	2011年9月4日	椿山ダム	日高川	和歌山県日高川町	1966/1988	
58	2013年9月16日	日吉ダム	桂川	京都府南丹市	1972/1997	台風18号
59	2014年8月10日	長安口ダム	那賀川	徳島県那賀郡那賀町	1950/1955	台風11号
60	2014年8月3日	鏡ダム	鏡川	高知県高知市	1960/1966	台風12号
61	2018年7月7日	野呂川ダム	野呂川	高知県高知市	1969/1975	台風7号・梅雨前線
62	2018年7月7日	野村ダム	肱川	愛媛県西予市	1971/1981	
63	2018年7月7日	鹿野川ダム		愛媛県大洲市	1953/1958	
64	2018年7月7日	河本ダム	西川	岡山県新見市	1958/1964	
65	2018年7月7日	新成羽川ダム	成羽川	岡山県高梁市	/1968	

注意：上記は洪水が発生し，同じ降雨によりダムが特例操作，またはそれに類似する放水を行った事例であり，放水が洪水の起因であるか否かの判断はここでは行っていない．

主な情報源：読売新聞，朝日新聞，毎日新聞の各オンラインデータベース，ダムの河川名，所在地，着工/竣工年はDamMaps(http://www.dammaps.jp/)ほかを参考にした．

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Disaster Tradition and Disaster Education of 2008 Sichuan Earthquake

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When human beings try to do "disaster prevention", first of all, we are trying to prevent or reduce the assumed damage by clarifying disaster related things, especially the cause and mechanism of its occurrence, assuming the damage caused by the disaster . When realizing such a process that can be considered as "disaster prevention" in general, so-called disaster prevention experts such as researchers targeting natural disasters and administrative staff who formulate and implement laws and policies are the protagonists It plays a leading role as. In order to systematically study the prevention and reduction of damage in an objective way systematically, we will call such disaster prevention activities "disaster prevention science" in this research. It is believed that promoting "disaster prevention science", clearly informing its necessity, and surely implementing disaster prevention measures is the goal of "disaster prevention" now. One typical example is evacuation drills at school. Because it is clear that it is possible to reduce damage by carrying out evacuation drills, evacuation drills are actually spreading to schools throughout Japan. Currently, the majority of "disaster prevention" is putting power to such a goal. In other words, it can be said that equal signs are drawn between "disaster prevention" and "disaster prevention science". It is generally considered that "disaster prevention" education is to make things already evident as the necessity of disaster prevention, and to make things not done possible. Disaster prevention experts and general citizens are considered to be "disaster prevention" success if they can work together to achieve this situation. But what about the reality? Humans understand, but there are many things that they do not do. Even if we tell the citizens that decided measures based on "disaster prevention science" are decidedly effective as it is, they are often procrastinated or ignored. For example, according to a survey conducted by the Cabinet Office in Heisei 29, regarding "measures taken in preparation for a major earthquake," I fixed furniture, home appliances, etc. and did not mention falling, falling, and moving " People are 49.4% of respondents. And as a reason for not doing that, reasons such as "I'm trying to do but postpone it" or "It's awkward" are high ranked. On the other hand, human beings, as higher animals in the natural world, have been associating with nature for many years, touching important matters without knowing, and continuing to do it accidentally over the long term. No, it may not be a coincidence. Even if it is not scientific, it sometimes has the effect of calling disaster against disasters. It is a lifestyle habit useful for disasters even if people in Nepal always place water storage tanks on the roof for daily water cutoff measures. Even in Japan, after the Niigata Prefecture Chuetsu Earthquake occurred, the avalanche broke the road and could not transport necessary food and goods for evacuation. The ingredients that were useful at that time were the ingredients and firewood that the local residents had prepared before entering the winter. Neither bother to go for disaster prevention, but as a result it leads to disaster prevention. There are other things that wisdom that has already been implemented in the life like this "can actually do such a view from the viewpoint of disaster prevention" or "there is surprising effect when used in this way". Discovery, protection and dissemination of these are also considered to be a kind of disaster prevention education. Therefore, in this research the above idea also applies to disaster dragging. In other words, its approach differs depending on the country and region in disaster transmission, and aims to learn about the new approach of disaster transfer from the difference. Specifically, the case of "Sichuan Earthquake" that hit China's Sichuan Province on May 12, 2008 is taken as a case. About 11 years after the earthquake, we investigate how the disaster is recorded in the affected area and how we are trying to communicate it to posterity people in that way and compare it during the day. Based on the results of the hearing survey conducted by Youth in Chengdu and the future disaster prevention experience hall,

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several disaster prevention education facilities, disaster transmission facility, we report on the new approach and disadvantage of disaster trading in Japan.

Keywords: Disaster Education, Disaster Tradition , 2008 Sichuan Earthquake

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Preparedness for Nankai Trough Earthquake: Incorporating Understandings of Uncertainties in Disaster Prevention Education Schemes

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For better disaster prevention education schemes to prepare for disasters, it is essential to examine how we address large-scale disasters with uncertainties which we have never experienced before, such as Nankai Trough earthquake. Specifically, how to incorporate “uncertainty” aspect into disaster prevention education and how to link the learnings into practices for better disaster preparedness is a critical challenge we are facing. The “uncertainty” is not a small component for disaster prevention. Rather, understandings of the reality of “uncertainty” at both scientific and social levels in terms of when, where, and how earthquakes may occur, affect the overall practical level of preparedness for disasters.

Given the above, addressing uncertainties is a challenge which multi-stakeholders need to work together, including natural and social scientists, policy communities, emergency practitioners, local governments, businesses, schools, and the public through collaborative learnings during normal times. For these learnings, it is critical for disaster prevention education to play a role. Especially the education schemes need to take into consideration: 1) how to make a common ground for understandings of uncertainties among multi-stakeholders based on available scientific information, 2) how to incorporate the understandings of uncertainties into learning process, and 3) how to direct the learnings into practices for better disaster prevention.

Based the above, a study group in Kyoto University where natural and social scientists collaboratively work together, have been seeking for the ways for addressing the reality of earthquake risks and uncertainties for different stakeholders through a series of workshops for the past three years. The presentation will report on the findings and insights drawn from the workshops targeted at education community (March, 2017), business community (June, 2017), civil disaster prevention community (March, 2018), and multi-stakeholders (January, 2019).

Specifically, the series of workshops were designed collaboratively by natural and social scientists with the focus on 1) scenario-based, 2) stakeholder-based, 3) site-based, and 4) dialogue-based or interactive-learning- based contexts. Especially, to optimize the learnings of earthquake risks and uncertainties, the workshops created processes for each participant to understand the uncertainties through themselves by applying it to their own daily lives or work settings.

Based on the workshops, overall, we have seen:

On the same table, different people with different backgrounds share their responses, awareness, and insights, which led to strengthen each understandings of the reality of uncertainties. Before and after the workshop, almost all participants changed their literacy and mindsets for addressing uncertainties. For examples, participants responded to workshops with comments: “earthquake risks have uncertainties

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and it is important to act flexibly against the unexpected events”, “even as a person in charge in a company did not understand it before workshop”, and “I realized it is important to address “uncertainties” even if it is incomplete information.” As a collective knowledge from the workshop, as examples, from the one targeted for business, the following points were drawn:

- To provide any earthquake risk information is important even if the probability is low and uncertainty high. For this, information recipients’ literacy is necessary too.

- Providing information from authoritative institution is critical; since when we think about the real scenarios, information from SNS or other sources will be flooded.

- We need to think about not only BCP but also disaster risk management from daily basis, covering not only response, but also recovery.

Thus, based on the results drawn from the workshops, we will provide policy implications in terms of how to incorporate understandings of uncertainties in disaster prevention education schemes.

Keywords: Disaster Prevention Education, Nankai Trough Earthquake, Uncertainty, Forecast, Scenario-based Workshop

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Importance of issuing evacuation for individual family

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Japan is a disaster-prone country and there are many variety of natural hazards. The hazards and degree of the risk are quite different in individual small area depend on geography and the site of disaster source. Disaster management for individual family is necessary to protect citizens from disasters. Recent examples of disaster reduction activities in local community and school will be presented.

Keywords: disaster management, natural hazard, disaster reduction activity

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[J] Poster | G (General)：General

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_23

[G-01] Disaster prevention education

convener:Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education), Jiro Komori(Teikyo Heisei University), Shintaro Hayashi(Akita University Graduate School of Education)

Each time a serious disaster occurs, there are calls for better disaster prevention education in and around the stricken area, and such education is actually implemented. However, it is not extended to other parts of the nation. Although disaster prevention education really is needed across Japan, it tends to be implemented only in the directly affected locality of a catastrophic disaster. Moreover, even in affected areas, when 10 to 20 years have elapsed from a major event, with a decline in the number of survivors, there is less motivation to pass experiences and learning on to the next generation, despite the potential for such disasters to recur, tens or hundreds of years into the future. It is not easy to maintain conversations about disaster experiences through several generations. Consequently, effective disaster prevention education is provided only in the region stricken by a particular event, and it is practiced only for up to 20 years following the last disaster. As a result, provision of disaster prevention education has become less effective in many areas of Japan. This session focuses on the following two questions: (1) What kind of disaster prevention education can be practiced continuously nationwide? (2) How can such disaster prevention education be implemented in schools and educational sessions? We encourage anyone who wishes to help develop new disaster prevention education based on awareness of these issues to make a presentation in this session. Participation is not restricted to geoscientists; any person or group engaged in any domain of disaster prevention is welcome to submit a paper.

[G01-P01] Application of GSI's Products for Disaster Prevention Education

*Takaki Okatani[1] (1.Geospatial Information Authority of Japan, Ministry of Land, Infrastructure, Transport and Tourism)

[G01-P02] Reconstruction of the image of the debris flow of the1898 disaster at the southern foot of Yatsugatake and the possibility of raising awareness of the local residents

*Hitoshi Nakai[1] (1.Kobuchisawa Research Institute for Nature and Education)

[G01-P03] Provisional report of the questionnair survey results to junior high school students regarding to natural disaster

*Norihito Kawamura[1], Kyoichi Takahashi[1] (1.Faculty of Education and Human Studies, Akita University)

[G01-P04] Disaster prevention education on estimation of earthquake damage on the campus

*Takeshi Yamagata[1] (1.Department of Natural Sciences, Komazawa university)

[G01-P05] Report of disaster mitigation childcare in kindergarten

*Nobuyuki Yamada[1], Kaoru Choji[2] (1.Kochi University, 2.Wakayama University)

[G01-P06] Utilization of Digital Resources to Facilitate Disaster Prevention Comprehension

*Tadayoshi Kato[1] (1.Moegino JHS.)

[G01-P07] Disaster Triangle – A Conceptual Device for Implementing Comprehensive and Continuous Disaster Education into School Science –

*Yuko Nomura[1] (1.National Researcn Institute of Fire and Disaster)

[G01-P08] RECOMMENDATIONS FOR DISASTER EDUCATION FOCUSING ON GEOGRAPHICAL CHARACTERISTICS

*Kenta Kawakami[1], Nobuhisa Matsuta[1] (1.Okayama University Graduate School)

Application of GSI’s Products for Disaster Prevention Education

*Takaki Okatani[1]

1. Geospatial Information Authority of Japan, Ministry of Land, Infrastructure, Transport and Tourism

Geographical subject “Chiri-Sogo” (general geography) was decided to be set as newly compulsory subject of senior high-school in the next Course of Study which was revised in fiscal year 2017. Also, importance of utilization of maps and GIS (Geographical Information System) becomes larger and larger in the next Course of Study in geographical field. On the other hand, natural disaster in our country becomes more and more seriously in recent years; such as “Nishi-Nihon Gouu” (Heavy rainfall in western Japan) and “Hokkaido Iburi-Tobu Jishin” (Earthquake at eatern Iburi District in Hokkaido) were happened in the last year.

GSI (Geospatial Information Authority of Japan) has been supporting to geographical education; such as lectures to pupils, students and teachers. Such supports for disaster prevention education becomes more important as GSI regarded to play an important role in the national government.

GSI provides “Chiri-in Chizu” (GSI Maps) as a platform to serve GSI’s geospatial contents; such as basic maps and thematic maps. Information in such maps, geomorphology and land condition are useful for considering a risk of natural disaster which might be happened. Also, functions in “Chiri-in Chizu”; such as various ways of geomorphological expression, are useful for considering a risk of natural disaster.

GSI had examined its role for educational support with specialists in geographical education in fiscal year 2017-18, and it was pointed out that GSI should improve and strengthen its way of serving geospatial information. GSI is now taking actions for improvement of serving geospatial information.

In the presentation, the author expects to discuss how GSI should play a role in disaster prevention education.

Keywords: Disaster Prevention Education, Maps and Geographical Information System, Geospatial Information Authority of Japan

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Reconstruction of the image of the debris flow of the1898 disaster at the southern foot of Yatsugatake and the possibility of raising awareness of the local residents

*Hitoshi Nakai[1]

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On September 6-7, 1898, a typhoon brought continuous torrential rain which caused floods and severe damage in the whole of Yamanashi Prefecture. In particular, a debris flow occurred at 1:30 a.m. on September 7 at the southern foot of Yatsugatake, leaving 55 people dead and 51 injured in Yato village in Oizumi-mura. The author investigated newspapers published at that time, and the "National Disaster Pictures" and "Storm Damage Survey Tables," both compiled in the Meiji era and archived in the Imperial Household Agency. He also inspected the disaster-stricken area in detail, including carrying out a survey using a drone. The historical data indicate that the debris flow branched off in three directions at the exit of the ravine of Miyagawa. One went in the southeast direction, which was continuing in the direction of the ravine. The other two flowed south and southwest, respectively. The debris flow to the south struck Yato village and inflicted serious damage. With 110 years having passed since the event, not only what was caused by the debris flow but also the disaster itself has disappeared from the memory of most local people. In this paper, the author also explores the possibility of raising the awareness of the local residents by reconstructing the image of the disaster from historical documents and using modern techniques, such as computer simulation of the debris flow.

Keywords: disaster prevention education, Debris flow disaster, Historical document

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Provisional report of the questionnair survey results to junior high school students regarding to natural disaster

*Norihito Kawamura[1], Kyoichi Takahashi[1]

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The authors conducted questionnaire survey to the junior high school students in Akita and Chiba prefectures.
Difference of characteristics of natural disaster between two areas may cause conceptions by the students.

Keywords: questionanire survey, Akita Prefecture, Chiba Prefecture

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Disaster prevention education on estimation of earthquake damage on the campus

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In the Kanto region, active faults that generate M7 class earthquakes are now in active period. In particular, in each city in the metropolitan area, the probability that an earthquake with a seismic intensity 6 lower is generated within 30 years has increased to 48-85% (Headquarters for Earthquake Research Promotion, 2018). The Central Disaster Management Council (2013) sets the damage estimate to be about 23,000 deaths and about 95 trillion yen in economic damage when the M7 class earthquake occurs directly under the capital city. The Komazawa Campus, Komazawa University (Setagaya-Ku) may be hit by a major earthquake disaster.

The most recent huge earthquake at Komazawa campus is the Great Kanto Earthquake of 1923, and the seismic intensity by the earthquake is estimated to be 6 upper. However, the trace of the present earthquake disaster is only the earthquake-resistant building constructed as a reconstruction project remains. Under such circumstances, the memory of the earthquake disappears. The sweetness of the damage prediction against the disaster, and virtual sense of security can cause further expansion of damage at the occurrence of the earthquake (Ministry of Education, Culture, Sports, Science and Technology, 2007). The disaster prevention education should continuously cultivate "the ability to prepare necessary beforehand for disaster prevention with knowledge of disaster and disaster prevention science technology" and "the ability to defend against natural disasters and even to survive at the disaster," (Ministry of Education, Culture, Sports, Science and Technology, 2007). Particularly, it is important that we can ensure safety at my own discretion at the earthquake disaster (the survey report on correspondence of schools in East Japan great earthquake, Ministry of Education, Culture, Sports, Science and Technology, 2012). Furthermore, at university education, it is desirable to educate students to deepen their knowledge and understanding of disaster prevention and skills, so that they can contribute to local disaster prevention activities and projects. (Ministry of Education, Culture, Sports, Science and Technology, 2012).

Based on the contents that are necessary for disaster prevention education above, I taught using active learning on earthquake disasters for the next practice.
1. Mechanism of earthquake / seismic motion and understanding ofearthquake disaster
2. Virtual experiences of earthquake motion with seismic intensity of6-lower or greater
3. Image training to allow each person to detect danger at the earthquake
This education was tried in the 2018 freshets' leave year program class (40 students of the Department of Geography, Komazawa University). The contents of the lesson are as follows. Also, in order to measure the educational effect, we conducted a questionnaire survey for students before the first lesson and after the last lesson.

Lesson 1 Explanation on mechanism of the earthquake, earthquakemotions, and earthquake disasters

Lesson2-3 Virtual experiences of earthquakes by earthquake motionsimulators (Life Safety Learning Center, the Tokyo FireDepartment) and other educational materials

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Lesson4-7 Estimation of the damage situation of the classrooms and the evacuation route to the temporary meeting places on the campus from the classroom.
1) Location survey to estimate of the damage in the classroom and the evacuation route in the case of the seismic intensity 6-lower, by each group of 3 to 4 students
2) Estimation of the damage situation by location surveydata and grasp of hazards of each classroom and the
evacuation route at the occurrence of the earthquake.
3) Presentation on survey data and damage estimation byeach group

On the base of the questionnaire survey data, it is supposed that the students have grasped earthquake disasters as their own problems.

Keywords: practical lesson, earthquake, active learning, cultural education, university

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Report of disaster mitigation childcare in kindergarten

*Nobuyuki Yamada[1], Kaoru Choji[2]

1. Kochi University, 2. Wakayama University

We performed the practical educations for the disaster prevention childcare at various kindergartens and nurseries in Japan. Based on these activities, we will present the results of the disaster prevention nursing for infants at some kindergartens in the Wakayama city, Japan, and the questionnaire findings for their parents and workers of nursery after the practice. The city is the one of the area where the outbreak of the large-scale disaster caused by the strong ground motion and the tsunami are driven apprehensive in the near future. Therefore, to grasp the situation around of the kindergarten for disaster mitigation is an aim of this study. Based on the practice result of the disaster prevention childcare in such a kindergarten, we are going to improve the disaster mitigation education for infants.

Keywords: disaster mitigation childcare, kindergarten

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Utilization of Digital Resources to Facilitate Disaster Prevention Comprehension

*Tadayoshi Kato[1]

1. Moegino JHS.

It has been found that about 20% of the world’s earthquakes occur near Japan. Two recent examples are the Osaka earthquake (June 18, 2018) and the Hokkaido Eastern Iburi earthquake (September 6, 2018). The GNSS Earth Observation Network System (GEONET) and the High Sensitivity Seismograph Network Japan (Hi-net), among others, are maintained to detect huge earthquakes in Japan. They are used for the Earthquake Early Warning (EEW) system. And after an earthquake, such as the Tohoku Earthquake off the pacific coast, we use the Dense Ocean Floor Network System (DONET) to help us understand how the quake change the ocean floor crustal deformation. All of this data is available to the public, and it is possible to teach everyone about Japanese crustal deformation and seismic activity. But because large scale data processing and visualization are difficult, it cannot be easily utilized for Junior High School education. On the other hand, the digital resources of Dagik Earth are available as another option, and the improvement to active learning is significant.

In this study we created animations of sea level change of the KANAGAWA region using a topographic solution of 10meter DEM data from the Geographical Survey Institute of Japan (GSI). The newly created animations will help students understand how different sea levels can change the coastline visually. This will be a significant aid to student comprehension. Using these animations in Junior High School science and disaster courses, we hope to change people’s attitude towards nature; especially in relation to big earthquakes and big tsunamis.

Keywords: Disaster prevention learning, Digital materials

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Disaster Triangle –A Conceptual Device for Implementing Comprehensive and Continuous Disaster Education into School Science –

*Yuko Nomura[1]

1. National Researcn Institute of Fire and Disaster

While “mechanical devices” such as seismometers are used to observe concrete physical phenomena, “conceptual devices” that construct mental images in brains are used to understand complex and ambiguous phenomena. For example, a conceptual device “disaster” would evoke eruptions in brains of volcanologists, and fires in brains of fire protection engineers. New academic disciplines are emerging, all of which are associated with disasters in some way. When individuals or society must make a decision from a wide perspective, it is becoming more and more difficult for each expert to give a perspective wider than his/her own field. We need to develop and share a cross-disciplinary conceptual device that will generalize various disasters and give us increased visibility, in order that humankind might overcome devastating disasters together. In the field of fire protection, the “fire triangle (fuel, oxygen, and heat)” has been playing the role of conceptual device for understanding complex fire phenomena. The author explained a disadvantage of the fire triangle that could not describe transitions between states (ignition or extinction) triggered by interactions among various agents, and suggested that the “self-organization”, a conceptual device of complex systems consisting of a number of agents with non-linear interactions, might make it possible for us to comprehensively understand both social and natural phenomena (Nomura, 2019).

All phenomena in the world of nature, including those in human society that is a part of the world of nature, are governed by interactions among three elements: “matter”; “energy”; and “motion”. By illustrating these three elements interacting with each other and naming the illustration the “disaster triangle”, the concept of disaster that tends to be minimized in everyday life could be evolved into a universal concept with which we could analyze various disaster processes based on system thinking, that is the focus of the present paper. For example, if a phreatic eruption is analyzed with the disaster triangle, it is depicted as a conversion process of internal energy of superheated water (matter) into kinetic energy driven by a change in boundary conditions. Then volcanologists would become aware of the risk of boilover in crude oil tank fires more easily. For another example, Kimura (2017) depicted a typhoon as an analogy of combustion. Within cumulonimbus clouds, internal energy of water vapor (matter) is released as condensation heat that is transferred to ambient air, gives buoyancy, and maintains updraft (motion). In the case of a fire, internal energy of combustible material (matter) is released as reaction heat during combustion that is transferred to ambient air, gives buoyancy, and causes the chimney effect. According to Kimura (2017), “cumulonimbus clouds are something like chimneys.”

It is expected that potential disasters that are ignored in everyday life might be noticed systematically, if the disaster triangle would become a widely shared conceptual device in society and enhance comprehensive understanding of natural, man-made, and complex disasters. In the present talk, possibilities of disaster education in school science utilizing the “disaster triangle” will be discussed.

Keywords: disaster education, science education, fire safety education, concept of disaster, disaster triangle, science communication

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RECOMMENDATIONS FOR DISASTER EDUCATION FOCUSING ON GEOGRAPHICAL CHARACTERISTICS

*Kenta Kawakami[1], Nobuhisa Matsuta[1]

1. Okayama University Graduate School

The reason why disaster education is implemented in social studies education is that natural disasters are caused by natural phenomena affecting our daily life. Therefore, unless you know the mechanism of modern society, you can not understand the mechanism by which natural phenomena progress to natural disasters. It is important for disaster prevention measures to raise the ability to assume the occurrence of a disaster. For that, it is necessary to be familiar with the mechanism that supports modern society and the geographical conditions of the region.
The hazard map is a tool to understand geographical conditions and grasp the vulnerability in modern society and should contribute to the maturation of disaster prevention measures, but it is not fully utilized. Disaster prevention education has not established a valid method.The purpose of this research is to be familiar with the geographical conditions of the area and to propose a method for transferring regional culture as disaster education . Specifically, we are attempting to create short videos using children as a way to unconsciously input the geographical conditions of the area, even for people who are not particularly interested in disasters and areas.

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[J] Poster | G (General)：General

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_37

[G-01] Disaster prevention education

convener:Hitoshi Nakai(Kobuchisawa Research Institute for Nature and Education), Jiro Komori(Teikyo Heisei University), Shintaro Hayashi(Akita University Graduate School of Education)

Each time a serious disaster occurs, there are calls for better disaster prevention education in and around the stricken area, and such education is actually implemented. However, it is not extended to other parts of the nation. Although disaster prevention education really is needed across Japan, it tends to be implemented only in the directly affected locality of a catastrophic disaster. Moreover, even in affected areas, when 10 to 20 years have elapsed from a major event, with a decline in the number of survivors, there is less motivation to pass experiences and learning on to the next generation, despite the potential for such disasters to recur, tens or hundreds of years into the future. It is not easy to maintain conversations about disaster experiences through several generations. Consequently, effective disaster prevention education is provided only in the region stricken by a particular event, and it is practiced only for up to 20 years following the last disaster. As a result, provision of disaster prevention education has become less effective in many areas of Japan. This session focuses on the following two questions: (1) What kind of disaster prevention education can be practiced continuously nationwide? (2) How can such disaster prevention education be implemented in schools and educational sessions? We encourage anyone who wishes to help develop new disaster prevention education based on awareness of these issues to make a presentation in this session. Participation is not restricted to geoscientists; any person or group engaged in any domain of disaster prevention is welcome to submit a paper.

[G01-P01] Application of GSI's Products for Disaster Prevention Education

*Takaki Okatani[1] (1.Geospatial Information Authority of Japan, Ministry of Land, Infrastructure, Transport and Tourism)

[G01-P02] Reconstruction of the image of the debris flow of the1898 disaster at the southern foot of Yatsugatake and the possibility of raising awareness of the local residents

*Hitoshi Nakai[1] (1.Kobuchisawa Research Institute for Nature and Education)

[G01-P03] Provisional report of the questionnair survey results to junior high school students regarding to natural disaster

*Norihito Kawamura[1], Kyoichi Takahashi[1] (1.Faculty of Education and Human Studies, Akita University)

[G01-P04] Disaster prevention education on estimation of earthquake damage on the campus

*Takeshi Yamagata[1] (1.Department of Natural Sciences, Komazawa university)

[G01-P05] Report of disaster mitigation childcare in kindergarten

*Nobuyuki Yamada[1], Kaoru Choji[2] (1.Kochi University, 2.Wakayama University)

[G01-P06] Utilization of Digital Resources to Facilitate Disaster Prevention Comprehension

*Tadayoshi Kato[1] (1.Moegino JHS.)

[G01-P07] Disaster Triangle – A Conceptual Device for Implementing Comprehensive and Continuous Disaster Education into School Science –

*Yuko Nomura[1] (1.National Researcn Institute of Fire and Disaster)

[G01-P08] RECOMMENDATIONS FOR DISASTER EDUCATION FOCUSING ON GEOGRAPHICAL CHARACTERISTICS

*Kenta Kawakami[1], Nobuhisa Matsuta[1] (1.Okayama University Graduate School)

Application of GSI’s Products for Disaster Prevention Education

*Takaki Okatani[1]

1. Geospatial Information Authority of Japan, Ministry of Land, Infrastructure, Transport and Tourism

Geographical subject “Chiri-Sogo” (general geography) was decided to be set as newly compulsory subject of senior high-school in the next Course of Study which was revised in fiscal year 2017. Also, importance of utilization of maps and GIS (Geographical Information System) becomes larger and larger in the next Course of Study in geographical field. On the other hand, natural disaster in our country becomes more and more seriously in recent years; such as “Nishi-Nihon Gouu” (Heavy rainfall in western Japan) and “Hokkaido Iburi-Tobu Jishin” (Earthquake at eatern Iburi District in Hokkaido) were happened in the last year.

GSI (Geospatial Information Authority of Japan) has been supporting to geographical education; such as lectures to pupils, students and teachers. Such supports for disaster prevention education becomes more important as GSI regarded to play an important role in the national government.

GSI provides “Chiri-in Chizu” (GSI Maps) as a platform to serve GSI’s geospatial contents; such as basic maps and thematic maps. Information in such maps, geomorphology and land condition are useful for considering a risk of natural disaster which might be happened. Also, functions in “Chiri-in Chizu”; such as various ways of geomorphological expression, are useful for considering a risk of natural disaster.

GSI had examined its role for educational support with specialists in geographical education in fiscal year 2017-18, and it was pointed out that GSI should improve and strengthen its way of serving geospatial information. GSI is now taking actions for improvement of serving geospatial information.

In the presentation, the author expects to discuss how GSI should play a role in disaster prevention education.

Keywords: Disaster Prevention Education, Maps and Geographical Information System, Geospatial Information Authority of Japan

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Reconstruction of the image of the debris flow of the1898 disaster at the southern foot of Yatsugatake and the possibility of raising awareness of the local residents

*Hitoshi Nakai[1]

1. Kobuchisawa Research Institute for Nature and Education

On September 6-7, 1898, a typhoon brought continuous torrential rain which caused floods and severe damage in the whole of Yamanashi Prefecture. In particular, a debris flow occurred at 1:30 a.m. on September 7 at the southern foot of Yatsugatake, leaving 55 people dead and 51 injured in Yato village in Oizumi-mura. The author investigated newspapers published at that time, and the "National Disaster Pictures" and "Storm Damage Survey Tables," both compiled in the Meiji era and archived in the Imperial Household Agency. He also inspected the disaster-stricken area in detail, including carrying out a survey using a drone. The historical data indicate that the debris flow branched off in three directions at the exit of the ravine of Miyagawa. One went in the southeast direction, which was continuing in the direction of the ravine. The other two flowed south and southwest, respectively. The debris flow to the south struck Yato village and inflicted serious damage. With 110 years having passed since the event, not only what was caused by the debris flow but also the disaster itself has disappeared from the memory of most local people. In this paper, the author also explores the possibility of raising the awareness of the local residents by reconstructing the image of the disaster from historical documents and using modern techniques, such as computer simulation of the debris flow.

Keywords: disaster prevention education, Debris flow disaster, Historical document

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Provisional report of the questionnair survey results to junior high school students regarding to natural disaster

*Norihito Kawamura[1], Kyoichi Takahashi[1]

1. Faculty of Education and Human Studies, Akita University

The authors conducted questionnaire survey to the junior high school students in Akita and Chiba prefectures.
Difference of characteristics of natural disaster between two areas may cause conceptions by the students.

Keywords: questionanire survey, Akita Prefecture, Chiba Prefecture

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Disaster prevention education on estimation of earthquake damage on the campus

*Takeshi Yamagata[1]

1. Department of Natural Sciences, Komazawa university

In the Kanto region, active faults that generate M7 class earthquakes are now in active period. In particular, in each city in the metropolitan area, the probability that an earthquake with a seismic intensity 6 lower is generated within 30 years has increased to 48-85% (Headquarters for Earthquake Research Promotion, 2018). The Central Disaster Management Council (2013) sets the damage estimate to be about 23,000 deaths and about 95 trillion yen in economic damage when the M7 class earthquake occurs directly under the capital city. The Komazawa Campus, Komazawa University (Setagaya-Ku) may be hit by a major earthquake disaster.

The most recent huge earthquake at Komazawa campus is the Great Kanto Earthquake of 1923, and the seismic intensity by the earthquake is estimated to be 6 upper. However, the trace of the present earthquake disaster is only the earthquake-resistant building constructed as a reconstruction project remains. Under such circumstances, the memory of the earthquake disappears. The sweetness of the damage prediction against the disaster, and virtual sense of security can cause further expansion of damage at the occurrence of the earthquake (Ministry of Education, Culture, Sports, Science and Technology, 2007). The disaster prevention education should continuously cultivate "the ability to prepare necessary beforehand for disaster prevention with knowledge of disaster and disaster prevention science technology" and "the ability to defend against natural disasters and even to survive at the disaster," (Ministry of Education, Culture, Sports, Science and Technology, 2007). Particularly, it is important that we can ensure safety at my own discretion at the earthquake disaster (the survey report on correspondence of schools in East Japan great earthquake, Ministry of Education, Culture, Sports, Science and Technology, 2012). Furthermore, at university education, it is desirable to educate students to deepen their knowledge and understanding of disaster prevention and skills, so that they can contribute to local disaster prevention activities and projects. (Ministry of Education, Culture, Sports, Science and Technology, 2012).

Based on the contents that are necessary for disaster prevention education above, I taught using active learning on earthquake disasters for the next practice.
1. Mechanism of earthquake / seismic motion and understanding ofearthquake disaster
2. Virtual experiences of earthquake motion with seismic intensity of6-lower or greater
3. Image training to allow each person to detect danger at the earthquake
This education was tried in the 2018 freshets' leave year program class (40 students of the Department of Geography, Komazawa University). The contents of the lesson are as follows. Also, in order to measure the educational effect, we conducted a questionnaire survey for students before the first lesson and after the last lesson.

Lesson 1 Explanation on mechanism of the earthquake, earthquakemotions, and earthquake disasters

Lesson2-3 Virtual experiences of earthquakes by earthquake motionsimulators (Life Safety Learning Center, the Tokyo FireDepartment) and other educational materials

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Lesson4-7 Estimation of the damage situation of the classrooms and the evacuation route to the temporary meeting places on the campus from the classroom.
1) Location survey to estimate of the damage in the classroom and the evacuation route in the case of the seismic intensity 6-lower, by each group of 3 to 4 students
2) Estimation of the damage situation by location surveydata and grasp of hazards of each classroom and the
evacuation route at the occurrence of the earthquake.
3) Presentation on survey data and damage estimation byeach group

On the base of the questionnaire survey data, it is supposed that the students have grasped earthquake disasters as their own problems.

Keywords: practical lesson, earthquake, active learning, cultural education, university

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All phenomena in the world of nature, including those in human society that is a part of the world of nature, are governed by interactions among three elements: “matter”; “energy”; and “motion”. By illustrating these three elements interacting with each other and naming the illustration the “disaster triangle”, the concept of disaster that tends to be minimized in everyday life could be evolved into a universal concept with which we could analyze various disaster processes based on system thinking, that is the focus of the present paper. For example, if a phreatic eruption is analyzed with the disaster triangle, it is depicted as a conversion process of internal energy of superheated water (matter) into kinetic energy driven by a change in boundary conditions. Then volcanologists would become aware of the risk of boilover in crude oil tank fires more easily. For another example, Kimura (2017) depicted a typhoon as an analogy of combustion. Within cumulonimbus clouds, internal energy of water vapor (matter) is released as condensation heat that is transferred to ambient air, gives buoyancy, and maintains updraft (motion). In the case of a fire, internal energy of combustible material (matter) is released as reaction heat during combustion that is transferred to ambient air, gives buoyancy, and causes the chimney effect. According to Kimura (2017), “cumulonimbus clouds are something like chimneys.”

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*Kenta Kawakami[1], Nobuhisa Matsuta[1]

1. Okayama University Graduate School

The reason why disaster education is implemented in social studies education is that natural disasters are caused by natural phenomena affecting our daily life. Therefore, unless you know the mechanism of modern society, you can not understand the mechanism by which natural phenomena progress to natural disasters. It is important for disaster prevention measures to raise the ability to assume the occurrence of a disaster. For that, it is necessary to be familiar with the mechanism that supports modern society and the geographical conditions of the region.
The hazard map is a tool to understand geographical conditions and grasp the vulnerability in modern society and should contribute to the maturation of disaster prevention measures, but it is not fully utilized. Disaster prevention education has not established a valid method.The purpose of this research is to be familiar with the geographical conditions of the area and to propose a method for transferring regional culture as disaster education . Specifically, we are attempting to create short videos using children as a way to unconsciously input the geographical conditions of the area, even for people who are not particularly interested in disasters and areas.

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[J] Oral | G (General)：General

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 103 1F

[G-02] Geoscinece Outreach

convener:Takeyuki Ueki(Faculty of Risk and Crisis Management, Chiba Institute of Science), Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Satoko Oki(Faculty of Environment and information Studies), Chairperson:Satoko Oki

The aims of Outreach and geoscience education are to encourage developments that raise public awareness of geosciences through schools and/or public outreach by not only educators but also researchers. Therefore, any presentation related with these aims will be welcomed to this session. Depending on schedule and venue,some presentation will be changed to Poster presentations.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[G02-01] Outreach of geography on general books

*Naoko HASEGAWA[1], Yuuki NAKAGAWA[1] (1.Ochanomizu University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[G02-02] **Dissemination of geographical and archaeological thinking by museum exhibitions: Practical approaches using three-dimensional models**

*Yuichi S. Hayakawa[1,2], Sahoko Aki[2] (1.Faculty of Environmental Earth Science, Hokkaido University, 2.Center for Spatial Information Science, The University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[G02-03] Introduction of Guide Skill Up Course and Its Effect in the Izu Peninsula Geopark

*Tsuda Kazuhide[1], Hiroshi Ono[1], Hiroshi Yamazaki[1], Akifumi Matsuo[1], Hideki Ono[2] (1.NPO Whole Earth Institute, 2.Izu Peninsula Geopark Promotion Conucil Bureau)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[G02-04] Testcase of Science Cafe with Confrontation Axis Considerd to Complex of Earth and Space Science

*Harufumi Tamazawa[1,2], Yuko Ikkatai[3] (1. Disaster Prevention Research Institute, Kyoto University, 2.Faculty of Fine Arts, Kyoto City University of Arts, 3.kabli Institute for the Physics and Mathematics of the Universe, University of Tokyo)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[G02-05] Literacy for Rumors of Earthquake Occurrence

*Yoshiaki Orihara[1], Masashi Kamogawa[2], Toshiyasu Nagao[1] (1.Institute of Oceanic Research and Development, Tokai University, 2.Department of Physics, Tokyo Gakugei University)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[G02-06] **Regional crustal movements and gigantic tsunami traces recorded by ghost forests: Importance of outreach activities and education for disaster prevention**

★Invited Papers

*Kiyoyuki Shigeno[1], Futoshi Nanayama[2,6], Kazuaki Watanabe[2], Masayuki Ishii[3], Kazuhito Ishiwata[4], Shigeto Inokuma[5], Keita Fukatsu[7] (1.Meiji consultant co.,Ltd., 2.Geological Survey of Japan, AIST, 3.Ishii Professional Engineer Office, 4.Betsukai municipal museum, 5.Nemuro City museum history and nature, 6.CWMD, Kumamoto Univ., 7.Notsuke Peninsula Nature Center)

Outreach of geography on general books

*Naoko HASEGAWA[1], Yuuki NAKAGAWA[1]

1. Ochanomizu University

Publication of general books (books for general readers) is a way of outreach. We analysed recent general books of geography, on the point of writer’ s profession (researchers, teachers, others, etc.), their’ s contents, and those relationships.

Reserchers write geoscience, including physical geography. Middle and high school teachers, write whole contents of geography (general geography), which they learn in middle and high school. Writers as side business didn’ t write geoscience and general geography, they wrote especially on excursion.

Keywords: outreach, geography, general books

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Dissemination of geographical and archaeological thinking by museum exhibitions: Practical approaches using three-dimensional models

*Yuichi S. Hayakawa[1,2], Sahoko Aki[2]

1. Faculty of Environmental Earth Science, Hokkaido University, 2. Center for Spatial Information Science, The University of Tokyo

The way of thinking in geography and archaeology are sometimes similar to each other in that they comprise both the spatial and temporal contexts. Geography is more spatial-oriented, while archaeology is more temporal-oriented. The outreaching collaboration of geography and archaeology would, therefore, be effective in developing the ability of thinking in a spatiotemporal context. Such the collaboration of geography and archaeology can be presented in a museum exhibition. Although the number of museums specifically designed for geography is limited in Japan, there are numerous archeological museums in which geographical contents can also be included. Here we discuss the effects of a museum exhibition on the dissemination of geographical and archaeological thinking by their collaborative works. In particular, three-dimensional models of landforms and landscapes are utilized to promote the geographical and archaeological thinking for the visitors. The case studies include several museum exhibitions in Aomori, Fukushima, Nagano, and Kyoto Prefectures, each of which showed different appearances of the exhibitions. The approaches using 3D models were supposed to be informative directly letting the visitors feel and think the geographical and archaeological contexts behind the models.

Keywords: art, museum, children, geographical thinking, three dimensional

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Introduction of Guide Skill Up Course and Its Effect in the Izu Peninsula Geopark

*Tsuda Kazuhide[1], Hiroshi Ono[1], Hiroshi Yamazaki[1], Akifumi Matsuo[1], Hideki Ono[2]

1. NPO Whole Earth Institute, 2. Izu Peninsula Geopark Promotion Conucil Bureau

[Introduction]
Generally, the material (volcano, mineral, topography, etc.) picked up at the geopark has an impression that it is professional and difficult to understand. The significance of existence of "attractive and meaningable geo guide" is great.
This report examined the lecture focusing on "transmitted technology" against the certified geo guide at the Izu Peninsula Geopark. We designed a lecture aimed at aiming to be able to express "exactly more easily" the expert knowledge that students have accumulated through various training etc. so far.

[Method]
The subjects were conducted on 30 Izu Peninsula certified geo guides in November to December 2018 once a week from 10:00 to 16:00 as shown below, with five contents.
As the 5th monitoring tour, we distributed a leaflet at the 1st lecture and started recruiting.
In addition, we conducted a questionnaire after each lecture, and tabulated the evaluation and effect of the course.

1. Guidance, How to make a place, Mental attitude of the guide
After confirming the flow of 5 times and treating it as a guidance of the course, learn how to start a program smoothly with the participants. Learn how to relate the guide to visitors and the mental attitude required to face the guide.

2. Transmission technology, Field tour, Lecture
The instructor carried out a simple geo tour for students. In the afternoon, we will give lectures and discussions on the "transmitted technology" that the instructor has taken in.

3. Program design, Sharing of guide methods
Learn the flow and composition of the program to effectively "transmit".Also, set up time to share daily guidance techniques and tools you are using among participating guides.

4. Program planning, Rehearsal
Organize 4 to 5 teams. Incorporate the techniques and ideas learned in the past three courses, and prepare a program for elementary school upper grades (about 15 minutes). Also suppose it will be rainy on that day.

5. Practice, Program execution
Provide programs created for primary school students , upper grades. While doing questionnaire and retrospect, notice what you got in the whole and take it their lifestyle.

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[Results]
According to the results of the questionnaire, almost everyone was satisfied with the contents in each lecture. For students that answered that they could leverage what we learned in this course to their own program and were able to say the direction of how to communicate to geo tour.
Towards the actual implementation of the program created by the team to elementary school students, sometimes from lecturers and talks between students, the trick to assembling tips and programs, the process of discovering each other's potential , As the number of times repeated, the students became robust.
In addition, there were few students who gave a problem point, many positive opinions were received. Hospitality of drinks and music, etc. that create a relaxing space, group activities, drawing out the voluntariness of students, cooperativeness There are many opinions that we would like to continue, etc., and a constructive opinion went up to make it better.

Keywords: Geo guide, Skill up course, Transmissing techniques

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Testcase of Science Cafe with Confrontation Axis Considerd to Complex of Earth and Space Science

*Harufumi Tamazawa[1,2], Yuko Ikkatai[3]

1. Disaster Prevention Research Institute, Kyoto University, 2. Faculty of Fine Arts, Kyoto City University of Arts, 3. kabli Institute for the Physics and Mathematics of the Universe, University of Tokyo

Science policies related to earth and planetary science include those with large scale, especially in connection with space science, and it is not clearly shown what kind of consciousness the public has due to high expertise, and as a result experts is the field. On the other hand, as far as the development of science and technology (ST)as well as space development, dialogue about science and technology with the public is shown as a goal from the government, and it is one thing to grasp what the public think about the policy Department. In the social survey on the space policy conducted on the Internet in 2014, the difference of images between space development and other ST policies, etc. are also being investigated, but on the other hand, regarding the specific budget allocation, It is difficult to judge whether or not you have a concrete image, such as answering to do (Fujita &Taromaru 2015). In 2017, we conducted an interview survey on why I responded to respondents after asking about the same contents, but some anserwed that it is difficult to consider space development compared to ST related to daily life (Tamazawa et al. 2018). Town meetings and public comments are being held as concrete attempts to foster opinions while encouraging citizens to feel familiar. It is a question to be examined including knowing how citizens think and thinking about how to reflect it in policy and effective method development.

Assuming to examine individual policy issues, it is necessary to share the process of grasping the background of the problem and organizing the problems, and how to visualize the problem and to discuss it is a challenge. is there. Especially, event formats such as those provided by a single science cafe, such as those provided by a regular science cafe, can deviate from the purpose of "gathering opinions" due to the information transmission and reception between participants and host. What type of format is effective to encourage participants to have their own opinions and think subjectively.

In January 2018, in a science café in a science café at the wine bar, a discussion on ST and society at the university, two topic donors were discussed and opinions of the participants were chronologically aligned We made a test case of a science cafe in a controversial style, taking the approach of visualizing. Under either theme "Setting the environmental change of Mars is allowed", from the topic provider, after giving representative opinions from the standpoint of favor and opposition, after agreeing and opposing axes on the white board , And asked the magnet to indicate the position of the participant's opinion. In order to see the transition of opinion after discussion among the participants, they asked for the position of opinion again after the discussion.

In the case of doing it in a university class, after the initial opinion, we had a discussion by the group including approval and opposition for each group, asked for suggested criteria and presented the opinions of the individual again There were participants who changed opinions on the other side from the viewpoint of environmental ethics, generation ethics, diversity. On the other hand, participants who strongly agreed or opposed from the beginning did not see much change.

In the event held at the wine bar, the agreement side agreed more, the other side moved the opinion to the other side more. There was an opinion that the opinion after the end of the science cafe considered

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taking care of participants into consideration. In both cases, it turned out that the position of the participants varied to some extent through the visualization of opinions, and that there were constant layers of standing position changes with the discussion. In general events related to ST such as science cafe, there is a tendency for people with a high level of interest in science and technology to participate (Kano, Mizumachi et al.), And such layers include a place of opinion such as question and answer at the event If there is, there is a possibility that the speaking participant may stand behaving apart from its own opinion transition, contributing to facilitation and activation of the discussion, on the other hand, excessive role consciousness is said to be a citizen's awareness From the point of view it may be possible that it is separate from the person's own opinion.

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This work is supported by JSPS KAKENHI Grant Numver JP18H05296.

Keywords: Public Engagement of Science, Science Policy, Scinece Cafe, Active Learning

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Literacy for Rumors of Earthquake Occurrence

*Yoshiaki Orihara[1], Masashi Kamogawa[2], Toshiyasu Nagao[1]

1. Institute of Oceanic Research and Development, Tokai University, 2. Department of Physics, Tokyo Gakugei University

A rumor of earthquake occurrence has often emerged after the most of large earthquakes (EQs), such as the 2016 Kumamoto EQ (Magnitude: M7.3) and the 2018 Hokkaido Eastern Iburi EQ (M 6.7). In the Kumamoto EQ, one of the hotels in Kochi prefecture was temporally closed due to the rumor. After the large EQs, the other false rumors such as animal escaping from the zoo and stop the supply of public water also emerged. In addition, the rumor of EQ occurrence often emerges not only after the large EQs but also during the aseismic period. In this study, we introduce features of the rumors of EQ occurrences and discuss literacy for them to identify the false rumors.

Keywords: rumor of earthquake occurrence, literacy

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Regional crustal movements and gigantic tsunami traces recorded by ghost forests: Importance of outreach activities and education for disaster prevention

*Kiyoyuki Shigeno[1], Futoshi Nanayama[2,6], Kazuaki Watanabe[2], Masayuki Ishii[3], Kazuhito Ishiwata[4], Shigeto Inokuma[5], Keita Fukatsu[7]

1. Meiji consultant co.,Ltd., 2. Geological Survey of Japan, AIST, 3. Ishii Professional Engineer Office, 4. Betsukai municipal museum, 5. Nemuro City museum history and nature, 6. CWMD, Kumamoto Univ., 7. Notsuke Peninsula Nature Center

Coastal topography and tsunami deposits caused by trench type earthquakes can be clearly observed around the Kuril subduction zone, eastern Hokkaido. We conducted a geological excursion on the theme of geological phenomena caused by giant earthquakes, which can be participated by local citizens on September 3-4, 2018 as a related event of the 125th annual scientific congress of the Geological Society of Japan in Sapporo. In this excursion, we taught that future disasters can be predicted based on the past information from strata and topography recorded during the past several thousand years. And these are useful for teaching materials for students. We also hope that local citizens will consider future giant earthquake and tsunamis and disaster prevention using peel specimens of tsunami deposits for local museums, etc.

Keywords: outreach activities, awareness activities, tsunami deposits, related regional crustal movements, giant earthquake

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[J] Oral | G (General)：General

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 103 1F

[G-02] Geoscinece Outreach

convener:Takeyuki Ueki(Faculty of Risk and Crisis Management, Chiba Institute of Science), Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Satoko Oki(Faculty of Environment and information Studies), Chairperson:Naoko HASEGAWA

The aims of Outreach and geoscience education are to encourage developments that raise public awareness of geosciences through schools and/or public outreach by not only educators but also researchers. Therefore, any presentation related with these aims will be welcomed to this session. Depending on schedule and venue,some presentation will be changed to Poster presentations.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[G02-07] **Constructing quaking model in the geological club activity and discussion activities around crack investigation**

*Ryo S Nakamura[1] (1.Miyagi Rifu high school)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[G02-08] The Impact of Middle School Students' "BOSAI Narratives" on the Community of Tosashimizu City

*Risako Tokoro[1], Kei Usui[1], Ayana Kawasaki[2], Tosei Nagamatsu[3], Satoko Oki[2] (1.Keio University, Faculty of Policy Management, 2.Keio University, Faculty of Environment and Information Studies, 3.Keio Research Institute at SFC)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[G02-09] **Disaster Prevention Education Programs to Increase Risk Perception**

*Erina Hyuga[1], Hitomi Sasaki[1], Satoko Oki[1] (1.Keio University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[G02-10] Geoscience education for infants using geological specimen

*Naoki Morita[1,2], Mana Yasui[2,3], Hiroshi Hagiya[2,4] (1.Meisei University, 2.Non-Profit Organization Science and Art, 3.Waseda research institute for science and engineering, 4.Tokyo City University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[G02-11] Introducing Narrative Approach to Earthquake Disaster Prevention (BOSAI) Teacher Training: Practice in Saitama Prefecture

*Ami Pareek[1], Satoko Oki[1], Kohei Yamaguchi[1], Mirei Toba[1] (1.Keio University)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[G02-12] Practice of Disaster Education in Mexico: "Cultural Tuning" Based on Comparative Study of Public Educational Curriculum Between Japan and Mexico

*Takuya Iwahori[1], Genta Nakano[1], Katsuya Yamori[1] (1.Disaster Prevention Research Insutitute, Kyoto University)

Constructing quaking model in the geological club activity and discussion activities around crack investigation

*Ryo S Nakamura[1]

1. Miyagi Rifu high school

Our school region is standing on the field of active-fault "Nagamachi-Rifu" line.
Our school region is standing on the field of active-fault "Nagamachi-Rifu" line.
We have had activities upon the surrounding research, for the fault's activity and sediments research.
Therefore, we seeked leading method to make experimental motion in the class and science club activity.
I will talk about daily geological activities, also concern to against disaster education as follows;

(1) Leading method of sediment materials research
Students tried to find some geological faults on the ground. They found boling core samples above the faults and succeed to analyze sediments and mentioned volcanic ash contains.

(2)Constructed motor-controlled quaking apparatus
The quaking model plays much important rolls to mention real breaking phenomena. Our students discussed the several soil model made by corn and chocolate-flakes, and constructed quake mechanics. Firstly they quaked by the hand-quaked, but the reproducibility was lower level. Then they planned motor-controlled and made by steel cans and rubber plugs which everything found surroundings. Reproducibility and easy constructing is much valuable model to make leading geological methods.

(3)Discussed cracks on the building by the stress
Students found the cracks on the building to specific direction, they mentioned about ground stress characteristic. Essentially, our region is located the border between ocean and continental plates. They also discussed the effects made by flat-constructed grounds.

Keywords: Seismic experiments, Sediments, Crack investigation

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The Impact of Middle School Students' "BOSAI Narratives" on the Community of Tosashimizu City

*Risako Tokoro[1], Kei Usui[1], Ayana Kawasaki[2], Tosei Nagamatsu[3], Satoko Oki[2]

1. Keio University, Faculty of Policy Management, 2. Keio University, Faculty of Environment and Information Studies, 3. Keio Research Institute at SFC

Students of Shimizu Middle School, located in Tosashimizu City (Kochi Prefecture) has been writing short stories called “BOSAI Narratives” since 2016. In JpGU 2018, Nagamatsu presented on how the students themselves were influenced by writing them (Nagamatsu, 2018). This year, we will discuss the results of our study on how the narratives affected the students’ parents and other people in the community.

About Tosashimizu City and the “BOSAI Narratives”

Tosashimizu City is a provincial city with a population of 14,000 people; 47% of it being over 65 years of age. In 2012, the Japanese government announced that in the Nankai Trough Earthquake, the tsunami height estimation of the city can be as high as 34 meters (Cabinet Office, 2012). The announcement was meant to increase people’s awareness, but it resulted in leading some people to lose hope in surviving the earthquake (Sun, 2014 and Oki, 2017). However, the “BOSAI Narratives” seem to be changing the situation.

We developed the “BOSAI Narrative” with the teachers of Shimizu Middle School in 2016. It is a short story written by individual students imagining their own situation in the event of the Nankai Trough Earthquake. They could write about anything that they imagine to be happening at the time of the disaster, under the condition that they must end in hope.

Research Method

At the end of the school year 2017, we conducted a survey on all the parents of the community, who had read the “BOSAI Narratives” written by the students of that year. Out of the respondents, we selected 10 parents to interview individually in order to conduct further qualitative research on how they were impacted by reading the students’ narratives.

Results

Through careful analysis of the survey and interview results, we discovered the following: 1) readers obtained and understood information concerning the occurrence of earthquakes, despite its uncertainty. In other words, the students played the role of “translating” scientific language into a daily context; 2) moreover, readers began to reconsider their everyday lives; 3) readers have trust in the disaster preparedness education program itself; 4) how the readers are impacted relies heavily on their individual backgrounds; 5) the narratives do not necessarily induce readers in perceiving earthquakes subjectively; 6) some readers learned to seek value in living the moment; 7) the narratives exposed the readers to other worlds and situations (term in Japanese: “guuyusei”) (Yamori, 2007); 8) the narratives’ setting to “end in hope” led some readers to imagine the opposite situation; thus 9) empowering readers to contemplate disaster (Yamori, 2007); and lastly 10) as for the interviewees in this study, most of them had already taken preventive measures prior to reading the narratives. Thus, only a few cases of behavioral changes were recognized in the narratives’ readers.

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Keywords: Education, Earthquake, Narrative

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Disaster Prevention Education Programs to Increase Risk Perception

*Erina Hyuga[1], Hitomi Sasaki[1], Satoko Oki[1]

1. Keio University

1. Introduction

The 2011 Great East Japan Earthquake raised awareness of the importance of disaster prevention education. Japan's Ministry of Education, Culture, Sports, Science, and Technology (2013) has emphasized the importance of developing education programs that nourish children's independence. However, a survey we conducted in 2015 revealed that it is difficult for school teachers to develop such programs for disaster prevention by themselves (Nagamatsu and Oki, 2015).

2. The "*Finding Risks in the Photo (FRP)* Class" and Photovoice method

This research will discuss a teaching material that we developed mainly for elementary school students. In it, named the "*FRP* Class", students are to look at photographs of themselves in certain situations and find items that may be dangerous when a large earthquake occurs. Since the students themselves are in the photos, they can perceive earthquakes as their own problems. In fact, we have been receiving reports that students became more proactive in learning about disaster prevention, and also became faster at reacting to earthquakes and drills (Oki, 2016).

The Photovoice method, established in public health studies, resembles the "*FRP* Class" in that it uses photos. By explaining to others about the pictures that they took, people find problems of themselves or their community. Originally in the "*FRP* Class", the students were pictured in the photos. This time, by applying the Photovoice method to the "*FRP* Class", each student became the photographer, rather than the subject. We investigated how their awareness of disaster risk management would change throughout the process.

3. Research methodology

We held a workshop on disaster prevention in Tsuruoka City, Yamagata prefecture, targeting students from Grades 2 to 4 in Tsuruoka and nearby cities. Participants took two pictures of their favorite places and sent them to us by e-mail in advance. During the workshop, the students learned about disaster prevention through various activities. Later in the workshop, we had the students introduce their favorite places to each other and explain its dangerous points. In the end, we assigned them to take pictures of the same place that they had taken beforehand, and to rethink about what they like, and what they think is dangerous about the place. We found that some took photos from different angles, to capture the dangers that had not been pictured in their previous photos. This suggests their ability to evaluate risks in actual earthquakes.

4. Results

We conducted a follow-up survey on some participants. As a result, almost all of them spoke of what they learned to their friends or family in addition to re-considering dangerous points. Furthermore, some reviewed their emergency bags and others discussed about evacuation sites. This corresponds to the three elements of study in the theory of "community of practice" (Lave and Wenger, 1991), that is 1)internalization of knowledge, 2)change of identity, and 3)expansion of learning community.

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disaster prevention to promote the ability to live.
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Geoscience education for infants using geological specimen

*Naoki Morita[1,2], Mana Yasui[2,3], Hiroshi Hagiya[2,4]

1. Meisei University, 2. Non-Profit Organization Science and Art, 3. Waseda research institute for science and engineering, 4. Tokyo City University

NPO Science and Art has developed natural science education in kindergarten since 2016.
The classroom runs a natural science class of 9 classes (60 infants and 8 elementary school students) every week. In this presentation we will introduce the following three programs and their educational effects.
1 ·Fossil Excavation Experience
2 ·Mineral Kaleidoscope
3 ·Dinosaurs Card Game
In the fossil excavation experience, the real ammonoid is embedded in the mixture material of gypsum plaster and sand. Children feel the excavation sensation with wooden sticks and rubber hammers. Let the fossils found by the children are made labels, and let them manage themselves as children's own collection.
Mineral Kaleidoscope program uses small stones such as quartz(purple/pink) and olivine to make a kaleidoscope. While observing the stone, develop a story to its origin and the topic of the production area.
In Dinosaur Card Game, while playing ordinary game, let children show and touch fossils (replicas, real fossils) of dinosaurs and marine
reptiles that appeared in Card.Teach children how to get dinosaurs information by using an picture books.
By introducing the feedback of this program, not only can infants earth science, but also includes the role of extending the interest afterwards. This program is proposed to be an excellent program in earth science education from early childhood.

Keywords: Early childhood education, Earth science education, Geological specimen

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Introducing Narrative Approach to Earthquake Disaster Prevention (BOSAI) Teacher Training: Practice in Saitama Prefecture

*Ami Pareek[1], Satoko Oki[1], Kohei Yamaguchi[1], Mirei Toba[1]

1. Keio University

1. Introduction

Since the March 11th, 2011 Great East Japan Earthquake occurred during the daytime when students were in class, the importance of disaster education again became the focal point of society. However, educators have expressed concerns regarding the topic (Nagamatsu, Oki, 2015). Although the effectiveness of disaster prevention education is well known, there are still numerous challenges to it. For example, working hours of school teachers greatly exceed “Karoshi level,” which is over 80 hours per month. Furthermore, the curriculum in public schools is widespread, in addition to fundamental subjects. In a curriculum where there is very little space for additional implementations, it is very difficult to teach disaster prevention education that the teachers themselves have never learned before. There are no teaching materials prepared, and at school, the teachers already have their hands full guiding their students and parents. In most schools, there is only one faculty member assigned to be in charge of school safety including disaster prevention, and in essence, that faculty member has to formulate an annual safety plan and a disaster prevention manual prescribed by the School Health and Safety Law by his/herself. Based on this manual, he/she is responsible for implementing disaster prevention education for that school. With the lack of time, experience, and budget, it is unreasonable to think that the faculty is capable of making improvements from the previous year's plan. As a result, only the continuation of evacuation exercises that have become a mere micromachining and a slight modification of the manual remains.

This presentation will report more efficient and effective ways of conducting earthquake disaster prevention teacher training, and also its achievements.

2. Research Methodology

This study was carried out to alleviate such confusion of the school site. We focused on teacher training, especially for disaster prevention education that is aimed to resolve problems mentioned before by introducing a narrative approach. Teachers are introduced to a hypothetical case in which a large earthquake occurs under school management - the expression and behavior of a child, anxiety, and frustration of a teacher is described in detail from a teacher 's perspective. Teachers are then asked to write out the risks inspired by reading this, participate in group work with other teachers in charge of the same grade, and to share thoughts in front of other teachers in that school. As a result of the training, it is made possible to raise awareness of tackling disaster safety within the entire faculty, and to visualize risks and reevaluate current evacuation methods. This program is 50 minutes in total. We also made handouts which support teachers to improve the evacuation drills after the training.

3. Activities in Saitama Prefecture and Progress

We have been working with two model schools (one public elementary school, and one public junior high school) in Saitama. First, we have done the teacher training, and after that we have done the follow-ups. Teacher training was a good opportunity for the teachers to think about disaster prevention. As a result, there were many activities done positively by school. For example, autonomously revising the evacuation drill, actively making a new plan for it and practicing it, etc. We have also conducted the follow-up surveys in the end of the year.

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Other than the activities of two model schools, all of the school principals in the city gathered for a meeting on July 2018. After the meeting there were positive reactions from some principals, that they were willing to do some activities of disaster prevention.

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Keywords: Disaster prevention, Education

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Practice of Disaster Education in Mexico: "Cultural Tuning" Based on Comparative Study of Public Educational Curriculum Between Japan and Mexico

*Takuya Iwahori[1], Genta Nakano[1], Katsuya Yamori[1]

1. Disaster Prevention Research Insutitute, Kyoto University

The purpose of this research is to compare curriculum of public education between Japan and Mexico with specific focus on knowledge of seismology. The authors at first review the public compulsory educational curriculum in each country, and secondly, carried out practice of disaster education in a university in Mexico City and analyzed the questioner survey of the class. As the result, the authors found that "plate tectonics" is the key to compare the system of the knowledge constructed in the course of public education in each country.

Keywords: Disaster education, Seismology, Mexico

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[J] Poster | G (General)：General

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_24

[G-02] Geoscinece Outreach

convener:Takeyuki Ueki(Faculty of Risk and Crisis Management, Chiba Institute of Science), Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Satoko Oki(Faculty of Environment and information Studies)

The aims of Outreach and geoscience education are to encourage developments that raise public awareness of geosciences through schools and/or public outreach by not only educators but also researchers. Therefore, any presentation related with these aims will be welcomed to this session. Depending on schedule and venue,some presentation will be changed to Poster presentations.

[G02-P01] Sand grain and the Earth - an educational attempt to show the crustal character by sand grain composition

*Hiroshi Hagiya[1] (1.Tokyo City University)

[G02-P02] Geology and geomorphology as seeds of lifelong learning

*Takeyuki Ueki[1] (1.Faculty of Risk and Crisis Management, Chiba Institute of Science)

[G02-P03] Educational effects in geoscience outreach through solid terrain models by desktop 3D printer

*Jiro Komori[1] (1.Teikyo Heisei University)

[G02-P04] Practice of environmental study utilizing local high-definition topographic data

*Takuro Ogura[1,2], Yuichi S. Hayakawa[3,4], Yasuhiko Tamura[4], Chiaki T. Oguchi[5], Masashi Morita[6], Kisara Shimizu[5], OGATA KEISUKE[7], Hiroyuki Yamauchi[4] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Graduate School of Environmental Sciences, Hokkaido University, 3.Faculty of Environmental Earth Science, Hokkaido University, 4.Center of Spatial Information Science, The University Of Tokyo , 5.Graduate School of Science and Engineering, Saitama University, 6.Faculty of Urban Innovation, Yokohama National University, 7.School of literature, Tsurumi University)

[G02-P05] Development of the hemispherical multi-touch panel for the rear-projection digital globe "Dagik Earth"

*Yukinobu Koyama[1], Naoki Hirota[1] (1.National Institute of Technology, Oita College)

[G02-P06] An interactive visualization system of earth observation satellite data using Dagik Earth and Joy-Con

*Ayane Kosugo[1], Hina Yamanuki[1], Zhiyan Liu[1], Kazuhito Ichii[1] (1.Center for Environmental Remote Sensing, Chiba University)

[G02-P07] The report of the International Earth Science Olympiad (IESO),2019

*Yutaka Takigami[1] (1.Kanto Gakuen University)

[G02-P08] 19th Children’s Summer School on Earthquake and Volcanoes in Izu-Oshima Geopark

*ai toma[1], tomoya hiiro[2], committee for children's Summer School on Earthquake and Volcanoes[3] (1.Keio University, 2.Graduate school of Shinshu University, 3.Seismological Society of japan・Volcanological Society of japan・Geological Society of japan)

Sand grain and the Earth - an educational attempt to show the crustal character by sand grain composition

*Hiroshi Hagiya[1]

1. Tokyo City University

Sand grain is not popular in secondary education, although vlcanoes, earthquakes, are important study subject in Japan. The difficulty to teach sand grain due to microscopic tecnic to identify each grain is not trained at most schools and universities in Japan.
Beautiful magnified sand grain observed by rupe and microscope, is often make students excited, and will be motive force to study earth science. The differences in grain composition, and grain morphology reflect the geological condition and climate, such as stable continent, volcanic arc, oceanic island, and tropic, arctic, humid, arid, etc.
A set of sand specimen, which include Japanese sand and continental sand, is effective to show the difference of geological character, and will realize that Japan stand on plate margins and have many volcanoes and uplifting so quickly that grains not enough weathered, compared to continental desert sand.
The sand specimens and grain data might to be integrated in museums and universities, it seems better to make open database and used to educational purpose in schools.

Keywords: sand, active margin, volcano, secondary education

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Geology and geomorphology as seeds of lifelong learning

*Takeyuki Ueki[1]

1. Faculty of Risk and Crisis Management, Chiba Institute of Science

Lifelong learning is a new education conceptualized in 1960’s and focused recently on local development. I conducted a class on lifelong learning for university students of business and economy courses. Two-days field work included contents of local history, culture, industry and nature, and emphasized an influence of geology and geomorphology to human activities. Geology and geomorphology are seeds of lifelong learning. This presentation reports an outline of field work and university students’ evaluation.

Keywords: lifelong education, field work, seeds, geology, geomorphology, local study

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Educational effects in geoscience outreach through solid terrain models by desktop 3D printer

*Jiro Komori[1]

1. Teikyo Heisei University

Outreach of geoscience study using the three-dimensional formed material with the precious 3D printer has been performed from 5 or 6 years ago (Shibahara, 2013). Recent price reduction allow introduction for education in a small organization, school and private (Honkyu, 2016). Thus, sharing information of printing methods and experience are important. This presentation will introduce practical example and reaction of the students in geoscience class and outreach event for middle school, high school, university and lifelong education. Printed material are mainly active volcano, or further granitic and limestone area, glacial, active fault, river terrace topography, and asteroids.

Keywords: school education, lifelong education, GSI digital web maps, hands-on, volcanic topography, case studies

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Practice of environmental study utilizing local high-definition topographic data

*Takuro Ogura[1,2], Yuichi S. Hayakawa[3,4], Yasuhiko Tamura[4], Chiaki T. Oguchi[5], Masashi Morita[6], Kisara Shimizu[5], OGATA KEISUKE[7], Hiroyuki Yamauchi[4]

1. Graduate School of Frontier Sciences, The University of Tokyo, 2. Graduate School of Environmental Sciences, Hokkaido University, 3. Faculty of Environmental Earth Science, Hokkaido University, 4. Center of Spatial Information Science, The University Of Tokyo , 5. Graduate School of Science and Engineering, Saitama University, 6. Faculty of Urban Innovation, Yokohama National University, 7. School of literature, Tsurumi University

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An interactive visualization system of earth observation satellite data using Dagik Earth and Joy-Con

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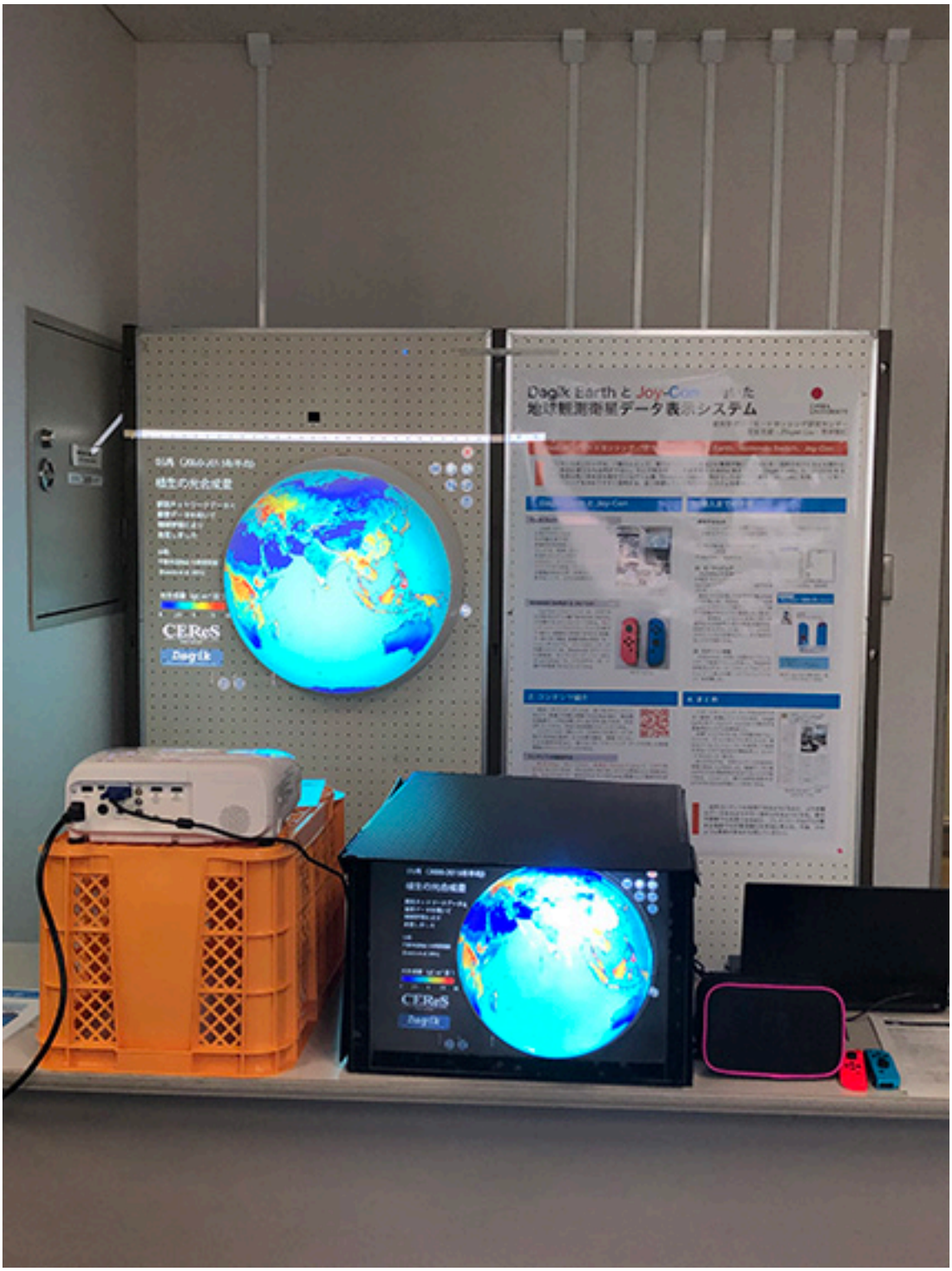

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19th Children’s Summer School on Earthquake and Volcanoes in Izu-Oshima Geopark

*ai toma[1], tomoya hiiro[2], committee for children's Summer School on Earthquake and Volcanoes[3]

1. Keio University, 2. Graduate school of Shinshu University, 3. Seismological Society of japan・Volcanological Society of japan・Geological Society of japan

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This time, with the theme of "Secret of volcanic island of Izu Oshima", about the history from the birth of the island to the present and the relationship with the community established there, experiments using outdoor observation and familiar materials, dialogue with researchers Through children, children understood the mechanism of volcanic eruption, deepened their understanding of nature's blessings, sightseeing, and natural disasters, and aimed to think about the island's past, present and future.Children deepen their understanding of the origins of the island from learning through fieldwork, indoor experiments and lectures.Children observed island’s topography, and learned lava rocks in the west side of Izu Oshima, the Motomachi area, and the structure of the inside of the caldera.Regarding geology, They observed the volcanic ash at the outcrop near the Oshima Onsen Hotel.They learned that gray white volcanic ash derived from Kozu Island was sandwiched and erupted on another island in a short period.They observed the lava, and learned the difference of the production of pahoehoe lava lava and aa lava.In the room, they carried out Caldera experiment, Magmatism experiment reproducing the nature and upward process of magma, lava experiment reproducing the movement and formation of Pahui Hui lava, and eruption experiment reproducing eruption style using Carbonation.

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Keywords: Committee for Children's Summer school on Earthquake and Volcanoes, Izu Oshima Geopark, Regional disaster prevention, Outdoor education, Kitchen Volcanology

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[J] Poster | G (General)：General

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_38

[G-02] Geoscinece Outreach

convener:Takeyuki Ueki(Faculty of Risk and Crisis Management, Chiba Institute of Science), Jiro Komori(Teikyo Heisei University), Naoko HASEGAWA(Ochanomizu University), Satoko Oki(Faculty of Environment and information Studies)

The aims of Outreach and geoscience education are to encourage developments that raise public awareness of geosciences through schools and/or public outreach by not only educators but also researchers. Therefore, any presentation related with these aims will be welcomed to this session. Depending on schedule and venue,some presentation will be changed to Poster presentations.

[G02-P01] Sand grain and the Earth - an educational attempt to show the crustal character by sand grain composition

*Hiroshi Hagiya[1] (1.Tokyo City University)

[G02-P02] Geology and geomorphology as seeds of lifelong learning

*Takeyuki Ueki[1] (1.Faculty of Risk and Crisis Management, Chiba Institute of Science)

[G02-P03] Educational effects in geoscience outreach through solid terrain models by desktop 3D printer

*Jiro Komori[1] (1.Teikyo Heisei University)

[G02-P04] Practice of environmental study utilizing local high-definition topographic data

*Takuro Ogura[1,2], Yuichi S. Hayakawa[3,4], Yasuhiko Tamura[4], Chiaki T. Oguchi[5], Masashi Morita[6], Kisara Shimizu[5], OGATA KEISUKE[7], Hiroyuki Yamauchi[4] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Graduate School of Environmental Sciences, Hokkaido University, 3.Faculty of Environmental Earth Science, Hokkaido University, 4.Center of Spatial Information Science, The University Of Tokyo , 5.Graduate School of Science and Engineering, Saitama University, 6.Faculty of Urban Innovation, Yokohama National University, 7.School of literature, Tsurumi University)

[G02-P05] Development of the hemispherical multi-touch panel for the rear-projection digital globe "Dagik Earth"

*Yukinobu Koyama[1], Naoki Hirota[1] (1.National Institute of Technology, Oita College)

[G02-P06] An interactive visualization system of earth observation satellite data using Dagik Earth and Joy-Con

*Ayane Kosugo[1], Hina Yamanuki[1], Zhiyan Liu[1], Kazuhito Ichii[1] (1.Center for Environmental Remote Sensing, Chiba University)

[G02-P07] The report of the International Earth Science Olympiad (IESO),2019

*Yutaka Takigami[1] (1.Kanto Gakuen University)

[G02-P08] 19th Children’s Summer School on Earthquake and Volcanoes in Izu-Oshima Geopark

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Sand grain and the Earth - an educational attempt to show the crustal character by sand grain composition

*Hiroshi Hagiya[1]

1. Tokyo City University

Sand grain is not popular in secondary education, although vlcanoes, earthquakes, are important study subject in Japan. The difficulty to teach sand grain due to microscopic tecnic to identify each grain is not trained at most schools and universities in Japan.
Beautiful magnified sand grain observed by rupe and microscope, is often make students excited, and will be motive force to study earth science. The differences in grain composition, and grain morphology reflect the geological condition and climate, such as stable continent, volcanic arc, oceanic island, and tropic, arctic, humid, arid, etc.
A set of sand specimen, which include Japanese sand and continental sand, is effective to show the difference of geological character, and will realize that Japan stand on plate margins and have many volcanoes and uplifting so quickly that grains not enough weathered, compared to continental desert sand.
The sand specimens and grain data might to be integrated in museums and universities, it seems better to make open database and used to educational purpose in schools.

Keywords: sand, active margin, volcano, secondary education

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Geology and geomorphology as seeds of lifelong learning

*Takeyuki Ueki[1]

1. Faculty of Risk and Crisis Management, Chiba Institute of Science

Lifelong learning is a new education conceptualized in 1960’s and focused recently on local development. I conducted a class on lifelong learning for university students of business and economy courses. Two-days field work included contents of local history, culture, industry and nature, and emphasized an influence of geology and geomorphology to human activities. Geology and geomorphology are seeds of lifelong learning. This presentation reports an outline of field work and university students’ evaluation.

Keywords: lifelong education, field work, seeds, geology, geomorphology, local study

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Educational effects in geoscience outreach through solid terrain models by desktop 3D printer

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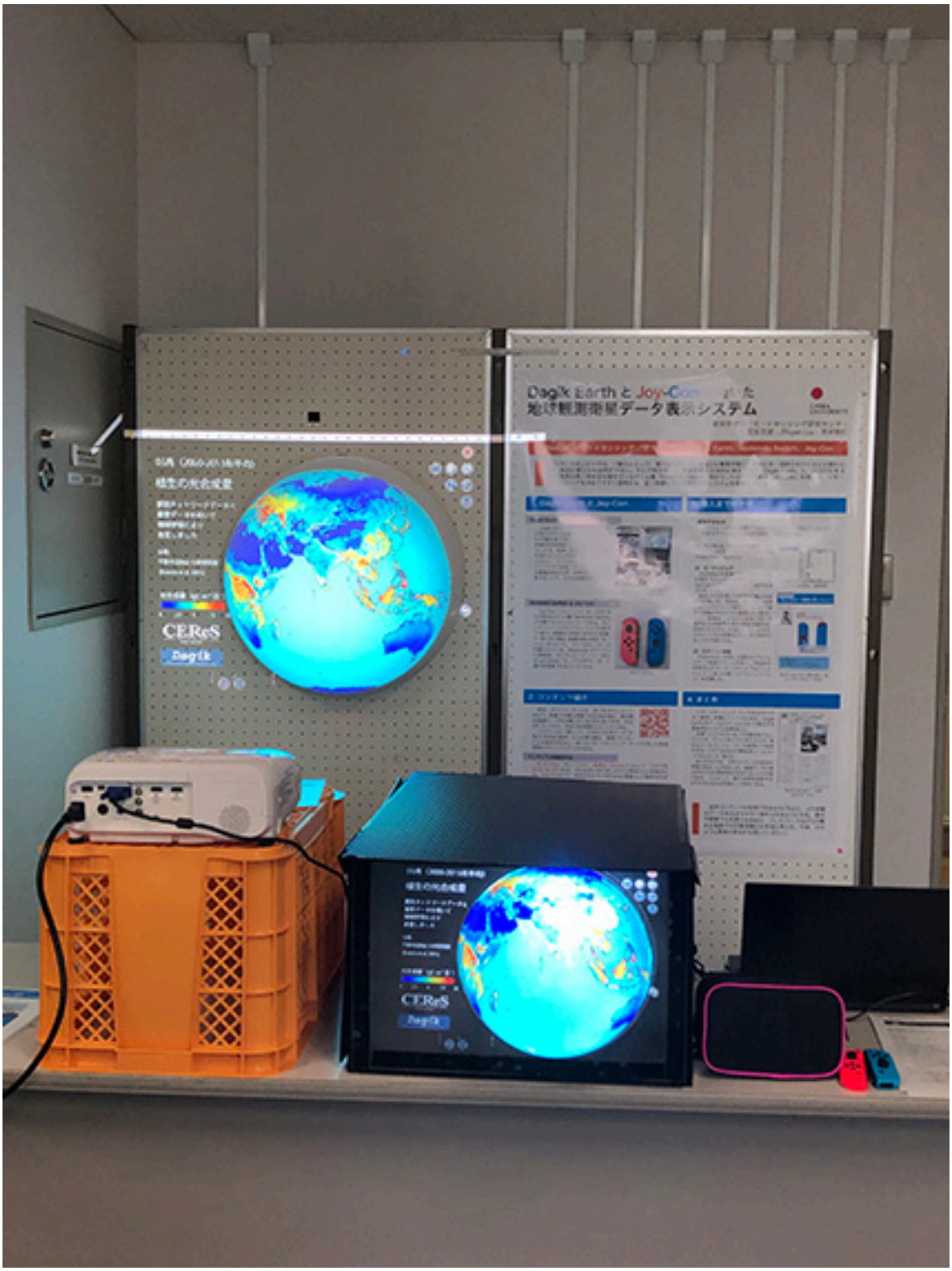

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[J] Oral | G (General)：General

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 104 1F

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School), Chairperson:Toshihiro Niwa

We will provide and discuss various educational practices (teachings and procedures) for elementary, junior high school, high school and university students. We also welcome outreach reports for all grades. In addition, especially for liberal arts level geoscience education of undergraduate, we will consider the problems and future prospects of our current situation.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[G03-01] "Science reading" in the Oki Island Library Let's science reading! The story of Light deliver "science reading and demonstration experiments in the Oki Island Library

*Kunihiro Abe[1] (1.Shimane Penunsula Shinjiko Narumi, Kuibiki Geopark Promotion Committee)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[G03-02] Difference in elementary students' understanding of a solar eclipse by using different ICT devices

*Koji Imai[1], Yasuhiro Murayama[1], Takahiro Yamanishi[2] (1.National Institute of Information and Communications Technology, 2.MITSUBISHI MINATOMIRAI INDUSTRIAL MUSEUM)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[G03-03] Let's learn landform and disaster risk

*Yuki Kurisu[1] (1.Geospatial Information Authority of Japan)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[G03-04] Demonstration of the serpentinite dehydration at a laboratory in school

*Soichi Omori[1], Yukinobu Katsumata[2] (1.The Faculty of Liberal Arts, The Open University of Japan, 2.Natural and Environmental Sciences Program, The Open University of Japan)

10:00 AM - 10:20 AM JST | 1:00 AM - 1:20 AM UTC

[G03-05] Educational activities of the Earth and planetary science in the collaboration of schools, science museums, and scientists using digital globe

*Akinori Saito[1], Takuya Tsugawa[2] (1.Department of Geophysics, Graduate School of Science, Kyoto University, 2.National Institute of Information and Communications Technology)

10:20 AM - 10:30 AM JST | 1:20 AM - 1:30 AM UTC

Discussion

"Science reading" in the Oki Island Library Let's science reading! The story of Light deliver "science reading and demonstration experiments in the Oki Island Library

*Kunihiro Abe[1]

1. Shimane Penunsula Shinjiko Narumi, Kuibiki Geopark Promotion Committee

Concept The phenomenon of the light seen on the island of Oki is stared again, and how the phenomenon might happen, and the light is learnt through the science reading and the demonstration experiment, and it hopes that the inquiring mind which tries to pursue it will grow up, and this course was done.

Basic content Need

light to see things Because there is a certain character in light, the shape of the one is seen and the color is seen. The nature of Light •light goes straight without any obstruction. Light goes straight while diffusing from the light source. •natural light source and artificial light source for light source -Reflection and reflection of light... In an object where light cannot pass, it reflects at the boundary surface, and the angle of incidence and reflection angle of the normal of the reflected surface of light are equally reflected. (Positive reflections and irregular reflection) The light has a color. (It leads to spectrum, wave, and interference in the future.) Three primary colors of light, rainbow The difference and shadow of black and white
The demonstration experiment was performed in such an idea.

Keywords: Visible light, straight, diffusion, light source, light and color, reflection

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*Koji Imai[1], Yasuhiro Murayama[1], Takahiro Yamanishi[2]

1. National Institute of Information and Communications Technology, 2. MITSUBISHI MINATOMIRAI INDUSTRIAL MUSEUM

To progress active learning by effective utilization of ICT devices, we studied three different learning methods of a solar eclipse for elementary school students: a passive learning method providing materials by a projector, an active learning method with a tablet, and a virtual experience learning method with a stereoscopic model. According to the results of the questionnaire survey about the degree of ease in understanding, the students answered that it was easy to understand using a tablet or model, and all students showed increased motivation for learning.

Keywords: solar eclipse, ICT, elementary student, active learning

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Let’s learn landform and disaster risk

*Yuki Kurisu[1]

1. Geospatial Information Authority of Japan

Education for disaster prevention is internationally attached importance as is the case with Sendai Framework for Disaster Risk Reduction 2015 - 2030. In Japan, course of study is promoted substantial education for disaster prevention and safety. Geospatial Information Authority of Japan (GSI) released education contents for learning landform and the disaster risk, provides the contents through toolbox for geography education (http://www.gsi.go.jp/CHIRIKYOUIKU/index.html). We would like to report about this contents. We devised three points in order to learner’s interest.

The first point is learning landform and the disaster risk with character. From geography point of view, they can learn disaster of mountainous areas, plain areas and coastal areas with resident. Finally, they can study disaster risk in familiar region using Hazard Map Portal Site.

The second point is interactive development of story. The introduction part leads them to think the relationship between landform and disaster with proverb. The development part has them considered disaster risk with cases and land condition. The conclusion part prompt them to reconfirm inseparable relationships with landform and the disaster risk.

The last point is easy representation of technical terms. They have to understand characteristics of river

in order to grasp flood. In the contents, we compare river a valley to a funnel.

GSI will continuously provide useful information about disaster risk such as this content and support geography education.

Keywords: Education for disaster prevention, landform, disaster risk

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Demonstration of the serpentinite dehydration at a laboratory in school

*Soichi Omori[1], Yukinobu Katsumata[2]

1. The Faculty of Liberal Arts, The Open University of Japan, 2. Natural and Environmental Sciences Program, The Open University of Japan

We report an experimental method to demonstrate the serpentine dehydration reaction at a laboratory in school. The aim of this study is illustrating the H_2O cycle between the surface environment and the mantle via hydrous minerals.

Keywords: hydrous mineral, serpentinite, dehydration reaction, labo experiment

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Educational activities of the Earth and planetary science in the collaboration of schools, science museums, and scientists using digital globe

*Akinori Saito[1], Takuya Tsugawa[2]

1. Department of Geophysics, Graduate School of Science, Kyoto University, 2. National Institute of Information and Communications Technology

Educational activities of the Earth and planetary science using Dagik Earth, a digital globe, have been carried out in the collaboration of schools, science museums, and scientists. Dagik Earth has been developed by Earth and planetary scientists in Kyoto University, NICT and others. Many scientists join the project to develop the contents using the Earth and planetary data. It is presented as permanent and temporal exhibitions in science museums. Some science museums have training seminars of Dagik Earth for school teachers. Because it is simple and easy to use, it is designed to use regular classrooms. The manual for teachers is developed for science and social class in elementary schools, junior high schools, and high schools in Japan. As the usage of Dagik Earth expands in the collaboration of schools, science museums, and scientists, the difficulties to use it in classrooms become clear. For example, the whole Earth is rarely taught in the science class in the elementary school because the study of the country-scale is more focused. In the presentation, current status of the project, its difficulties in schools, and the future plan will be reported.

Keywords: Digital globe, Dagik Earth, 3D presentation

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[J] Poster | G (General)：General

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_8

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School)

We will provide and discuss various educational practices (teachings and procedures) for elementary, junior high school, high school and university students. We also welcome outreach reports for all grades. In addition, especially for liberal arts level geoscience education of undergraduate, we will consider the problems and future prospects of our current situation.

[G03-P01] The ocean saline monitoring activities in the high school classes and science club activities as the ocean science education

*Ryo S Nakamura[1] (1.Miyagi Rifu high school)

[G03-P02] Collaboration between Visiting Lectures on Marine Science and Cubic Earth

*Yushi Morioka[1], Hiromichi Ueno[2], Naoki Fujii[3], Akihiro Senda[4], Tsuneo Ono[5], Sayaka Yasunaka[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Hokkaido University, 3.Saga University, 4.Japan Science Society, 5.Japan Fisheries Research and Education Agency)

[G03-P03] Understanding seismic waves propagating through the Earth's core graphically

*Mamoru Kato[1] (1.Graduate School of Human and Environmental Studies Kyoto University)

[G03-P04] Development of easy seismometer and fastest observations

*Shin'ichi Sakai[1], Satoshi Matsumoto[2], Yoshihisa Iio[3], Aitaro Kato[1] (1.Earthquake Research Institute, University of Tokyo, 2.Institute of Seismology and Volcanology, Faculty of Seiences, Kyushu University, 3.Disaster Prevention Research Institute, Kyoto University)

[G03-P05] Proposing an educationally supporting system, “rent a core” and “extract a core” service

*Takeyuki Ueki[1] (1.Faculty of Risk and Crisis Management, Chiba Institute of Science)

[G03-P06] Application of research data to junior high school, high school and university educations

*Norio Umemura[1], Yoshimasa Tanaka[2,3], Shuji Abe[4], Yasuo Saito[3], Shin ya Nakano[5], Atsuki Shinbori[1], Yasuyuki Minamiyama[3] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Polar Environment Data Science Center, Research Organization of Information and Systems, 3.National Institute of Polar Research, 4.International Center for Space Weather Science and Education, Kyushu University, 5.The Institute of Statistical Mathematics)

[G03-P07] The Education of Scientific Ethics of Science Research in Senior High School, a Pioneer in Japan

*Kazuya Kawakatsu[1] (1.Hyogo Prefectural Nishiwaki senior high school)

The ocean saline monitoring activities in the high school classes and science club activities as the ocean science education

*Ryo S Nakamura[1]

1. Miyagi Rifu high school

Ocean water quantity has the most value in the earth surface and environment. And saline was known as 3.5 vol% which contains mainly chlorides and sulfates.
In the educational scene, we need to inform school students not only authoritical published text's digit but also in situ observational experiments which can mention actual geoscience data. Therefore, now I attempt to construct short term continuously ocean saline measuring program in the geoscience class.

(1) Seeking activity where is the best suitable place to ocean saline measuring
At the science club, students used the regional coastal map which influenced with / without land water. Several seasons in the year scale duration might mention some global tidal tendencies. And the students constructed ocean water gathering system with used bottles and balls to collect saline contains with higher accuracy.

(2) Concentrated measuring saline-contains
In fact, the saline contains chlorides and alkali metallic cations, it is important what the apparatus measure. Therefore, the measuring activities includes also in-situ salinity evaporation. By the activities, students and teacher found some new knowledge about ocean saline contains which has also another tendency facts between Na^+ and K^+.

Keywords: Ocean saline, educational observation, Year-term alteration

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Collaboration between Visiting Lectures on Marine Science and Cubic Earth

*Yushi Morioka[1], Hiromichi Ueno[2], Naoki Fujii[3], Akihiro Senda[4], Tsuneo Ono[5], Sayaka Yasunaka[1]

1. Japan Agency for Marine-Earth Science and Technology, 2. Hokkaido University, 3. Saga University, 4. Japan Science Society, 5. Japan Fisheries Research and Education Agency

The Japan Oceanographic Society (JOS) has organized a series of visiting lectures on marine science, called “Umi-no-Demae-Jyugyo”, to enhance basic understanding of marine science and its fundamental role in socio-economic activity. Since 2016, 18 lectures have been performed at primary-high schools and public offices in Japan by the JOS registered professors and researchers. The topics of visiting lectures widely range upon request from basic marine science to cutting-edge marine science and technology, targeting at primary-high school children and teachers, etc. In 2018, the JOS has initiated a cross-sectoral collaboration with the Japan Science Society (JSS) to jointly support their activity on visiting lectures, so called Cubic Earth. The Cubit Earth, a virtual Earth having a cubic shape, involves complex ocean and atmosphere interaction system, but through comparison with the real Earth system, one can obtain deep insights into how the Earth’s environment has been developed into highly-diverse but stable system suitable for evolution of human beings. So far, two lectures on the Cubic Earth have been performed at high schools. This presentation aims to widely share examples of the performed lectures and key lessons learned from those lectures in order to raise awareness about significance of marine science among school teachers and children who join the JpGU meeting.

Keywords: Visiting lectures, Marine Science, Cubic Earth

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Understanding seismic waves propagating through the Earth's core graphically

*Mamoru Kato[1]

1. Graduate School of Human and Environmental Studies Kyoto University

In high school Earth Sciences, students learn how scientists use seismic waves to study the earth's internal structure. Discovery of the Earth's central core is one of the key topics presented in the textbooks, along with the introduction of the concept of the shadow zone. However, it is not easy to intuitively understand the behavior of seismic waves in the deep Earth, and this is one of the difficult topics to teach in classes. In this presentation, we will graphically summarize how the Earth's core influences the propagation of seismic waves using a simplified earth velocity structure model using trigonometric functions. Our method is similar to the ones used by Oldham, who was the first to suggest the existence on the earth’s core seismologically, and by Lehmann, who discovered the Earth’s inner core. We often teach the existence of core in relation to the history of seismology. Use of this proposed graphical method will help to understand such history as well. We demonstrate how to compute travel time curves using the simplified Earth velocity structure model using graphics and trigonometric functions.

Keywords: Earth's core, High School Earth Scieneces

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Development of easy seismometer and fastest observations

*Shin'ichi Sakai[1], Satoshi Matsumoto[2], Yoshihisa Iio[3], Aitaro Kato[1]

1. Earthquake Research Institute, University of Tokyo, 2. Institute of Seismology and Volcanology, Faculty of Seiences, Kyushu University, 3. Disaster Prevention Research Institute, Kyoto University

Seismic observation network has been deployed around Japan Islands in recent about 20 years. We need more dense data to reveal precise seismic mechanism and distribution. We developed a simple seismometer which is easy installation. One of the features of this seismometer is ultra-low power consumption. This seismometer keeps continuously working for one year by only 48 dry-cell batteries. Another of the features is easy fixing to the ground. Seismic sensors of the vertical component are insensible levelly and so they can be stick into the ground by bottom spike. They start with no difficult configuration and only same dip-switch. Telemeter observation without field collection becomes possible with SIM card. It could be installed easily, so it became easy to go to many observations with many stations. We introduce this seismometer and some example of use.

Keywords: easy installation, dence seismic observation, ultra-low power consumption

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Proposing an educationally supporting system, “rent a core” and “extract a core” service

*Takeyuki Ueki[1]

1. Faculty of Risk and Crisis Management, Chiba Institute of Science

Field work is not well carried out on earth science education in elementary, junior high and high schools in Japan. I propose an educationally supporting system, “rent a core” and “extract a core” service. Several junior high and high schools utilized this service in the last year. This presentation reports an outline of school classes and students’ evaluation.

Keywords: boring core, class, active learning, earth science education, substitution of field work

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Application of research data to junior high school, high school and university educations

*Norio Umemura[1], Yoshimasa Tanaka[2,3], Shuji Abe[4], Yasuo Saito[3], Shin ya Nakano[5], Atsuki Shinbori[1], Yasuyuki Minamiyama[3]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Polar Environment Data Science Center, Research Organization of Information and Systems, 3. National Institute of Polar Research, 4. International Center for Space Weather Science and Education, Kyushu University, 5. The Institute of Statistical Mathematics

ROIS (Research Organization of Information and Systems) has a plan to provide various kinds of research data with several universities and research institutions to education sites (junior high school, high school and university educations) in 2020 as a part of its data science business, in order to promote human resource development (information utilization, mathematicians and high level informatics skill) along with the Japanese government plan Society5.0.
As a first step, our preliminary project including Nagoya University and Kyushu University is now building a test platform including several scientific data (climatology data, environmental data, geology data, earth-space data, biology data and so on) managed by NIPR (National Institute of Polar Research). The detailed steps and functions are shown below:
- Data Archive: online archive to constantly provide research data,
- Data Information Appending: add basic data information, and valuable information to enable users to understand how the selected data contribute to their own field, and visualization result etc.,
- Data Proof: providing data for users to find data, identify data, select data and obtain data,
- Data Conversion: additional function to enable users to view/analyze/decide with general software,
- Data Fusion: additional functions to enable users to find related data.
Especially, data conversion is an important process to convert research data from research field-dependent format to general ASCII format, in order easily to view, analyze and decide the data, and leads to an enhancement of opportunities of scientific activities to users. Furthermore, data fusion is another process for computer to list similar data with statistical mathematical calculation, and strongly promotes mathematical activities for elucidating mechanisms which are the essence of science at the research and education sites.
In an official operation in 2020, we have a plan to expand the data we handle to more fields and more universities, and start human communications such as a school visit, application for teaching materials, extracurricular activities, and theme studies. We will start the high-knowledge cycle, make opportunities to reach the essence of science, and aim to produce talented persons with advanced knowledge to lead the advanced information society.

Keywords: Society5.0, elementary and secondary education, higher education, human resource development, information utilization, data science

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The Education of Scientific Ethics of Science Research in Senior High School, a Pioneer in Japan

*Kazuya Kawakatsu[1]

1. Hyogo Prefectural Nishiwaki senior high school

1. Introduction

In 2006, as soon as I started teaching science research, I felt it was the necessity of education of scientific ethics. At that time, Scientific Ethics that was not yet implemented nationwide was offered as a school setting subject. I authored textbooks. For example, during the research of the sarcophagus, the following problems occurred. When summarizing the study of the sarcophagus for the ancient Great King in the premises of the school, in order to realize the size of the sarcophagus, the pictures of the students lying inside were taken and posted. When students applied for this paper to Japan Science and Engineering Challenge, students were pointed out that this picture is ethically problematic. After that, the STAP cell problem was reported, and this led to active social debate about ethical consideration for scientists. In the new School Curriculum Guidelines for high schools implemented since 2021, a new subject Exploring the Science is set up. In this textbook, a certain amount of paper will be devoted to scientific ethics. Since research activities such as Science Research are being conducted at senior high schools, education of scientific ethics is essential.

2. Specific guidance contents and method

Scientists are required to learn expert knowledge and skills as necessary qualities and qualities, but even widowed people, basic knowledge and ethics for science are required. Of course not only for students who intend to become scientists and engineers in the future, students who do not regard scientists or engineers as future occupations, to judge correctly about various problems occurring in society or about to happen. It is necessary to train the consideration that learns the knowledge that can be done and enables objective judgment as an individual.

Learning about scientific ethics begins before the search activity begins in earnest, and it is carried out simultaneously with the research until the exploration activity finishes. After studying basic ethics, students are divided into groups of 4 to 5 students, and group work is conducted on the themes set by the students themselves. Teachers do not teach as much as possible and try to watch the students' voluntary discussions. Ethics is fostered by mutual discussion between students and the sharing of problems found newly from there, and it is not something that teachers can unilaterally teach. This group work is divided into three times a year. The result of the discussion will be released in the form of oral presentation for the first time, poster presentation for the second time, presentation of thesis for the third time. The thesis is written by each student in a theme corresponding to the course of each student. All the recital are published for teachers and students of other schools, guardians and local residents. In addition, the papers compiled by the students are collected as student research papers and distributed free of charge.

Scientific ethics classes are conducted in the form of team teaching by multiple faculty members.

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Continue checking with multiple different eyes until comment, in cooperation with science, mathematics, civil engineering, information, Japanese language, English, etc. centering on writers, in order to capture natural science in everyday life and connection with society, from educational contents to students.

3. Evaluation of Scientific Ethics

As education of scientific ethics progresses, the attitude of students to listen to news changes obviously. Students will be seen from critical viewpoint on the press and they will be judging things from a compound eye viewpoint. The teachers are paying attention to the contents and remark method which they had casually until now, and obviously the teacher's own ethics and human rights awareness are improving. Evaluate comprehensively with concrete evaluation items such as how participation in group research every class, and behavior at the poster session, etc.

Keywords: Science Research, Scientific Ethics, Group Work, Team Teaching, Compound Eye Viewpoint

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[J] Poster | G (General)：General

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_39

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[G03-P01] The ocean saline monitoring activities in the high school classes and science club activities as the ocean science education

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[G03-P02] Collaboration between Visiting Lectures on Marine Science and Cubic Earth

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*Takeyuki Ueki[1] (1.Faculty of Risk and Crisis Management, Chiba Institute of Science)

[G03-P06] Application of research data to junior high school, high school and university educations

*Norio Umemura[1], Yoshimasa Tanaka[2,3], Shuji Abe[4], Yasuo Saito[3], Shin ya Nakano[5], Atsuki Shinbori[1], Yasuyuki Minamiyama[3] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Polar Environment Data Science Center, Research Organization of Information and Systems, 3.National Institute of Polar Research, 4.International Center for Space Weather Science and Education, Kyushu University, 5.The Institute of Statistical Mathematics)

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[J] Oral | G (General)：General

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 104 1F

[G-03] Geoscience education from elementary school to university students

convener:Masatsune Hatakeyama(Seiko Gakuin High School), Chairperson:Masatsune Hatakeyama(Seikogakuin High school)

We will provide and discuss various educational practices (teachings and procedures) for elementary, junior high school, high school and university students. We also welcome outreach reports for all grades. In addition, especially for liberal arts level geoscience education of undergraduate, we will consider the problems and future prospects of our current situation.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[G03-06] **Improving Awareness of Marine Conservation and Sustainability among Taiwanese Middle School Students by Teaching Slow Fish Movement**

*Ya-Yin Liao[1], Liang-Ting Tsai[2], Ting-Kuang Yeh[3], Cheng-Chieh Chang[1] (1.National Taiwan Ocean University Institute of Education , 2.Taiwan Marine Education Center, 3.National Taiwan Normal University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[G03-07] Prototyping of the teachable moment presetation for recent earthquakes in Japan (2) - - -The case of the 3 January 2019 Kumamoto earthquake (M5.1) on and improvement from the previous prototype- - -

*Reiji Kobayashi[1] (1.Graduate School of Science and Engineering, Kagoshima University)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[G03-08] Development of web application for polarizing microscope observation

*Fumitoshi Morisato[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[G03-09] Usage and Utilization of 3D display function on GSI Maps

*Ryoichi Kojiroi[1] (1.Geospatial Information Authority of Japan)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[G03-10] Bringing field- and laboratory work into the classroom by using online modules in the edX platform

*Alejandra Quintanilla-Terminel[1], Matej Pec[1], Oliver Jagoutz[1] (1.Massachusetts Institute of Technology)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

Discussion

Improving Awareness of Marine Conservation and Sustainability among Taiwanese Middle School Students by Teaching Slow Fish Movement

*Ya-Yin Liao[1], Liang-Ting Tsai[2], Ting-Kuang Yeh[3], Cheng-Chieh Chang[1]

1. National Taiwan Ocean University Institute of Education , 2. Taiwan Marine Education Center, 3. National Taiwan Normal University

The ocean is the largest life support system on Earth. Through long-lasting evolution, an enriched variety of ocean specimens have been produced, thereby fulfilling human needs such as those of food, medicine, and marine recreation. Numerous marine products contain health-beneficial compounds; for example, oils obtained from multiple types of fish are enriched with Eicosapentaenoic acid (EPA) and Docosahexaenoic acid (DHA), which are beneficial to human eyes and brain development, respectively. Additionally, these components are immensely beneficial for controlling inflammation, lowering cholesterol, and replenishing calcium. Therefore, usage of marine products is closely related to the growth and development of the human body and regulation of its physiological functions; seafood is thus a key element of a healthy diet. However, human behavior and activities over the preceding ten years have posed the threat of damage to the health of ocean environments and productivity of marine resources. Hence, marine conservation and generating awareness of it is a pivotal task.

The study aimed at measuring the impacts of Slow Fish Movement curriculum on students’ marine purchasing and eating habits along with determining the changes in student’s understanding level regarding marine awareness and sustainability. For the same, a questionnaire designed for Slow Fish Movement (SFM) curriculum map with core values derived from Sustainable Development Goal 14 (SDG 14) in the United Nations, Slow Fish promotion in Italy, as well as Principles for Seafood Consumption Recommended by Taiwan Seafood Guide. The study objects were seventh and eighth-grade students of Er-Xin Middle School in Keelung city. The experiment lasted for three weeks. The experimental group contained 1,007 students and compared their performance difference with pre-test & post-test. Of the 1,070 questionnaires distributed, Invalid questionnaires were 63 and thus eliminated—resulting in 1,007 valid responses, the overall response rate was 94.11%. Before the SFM course, a pre-test was conducted to understand students' original knowledge, attitudes and behaviors in life about marine conservation and sustainability. After SFM course for three weeks, a post-test was conducted to understand if students improve understanding levels on ocean conservation and sustainability. After retrieval and sorting of the responses, the statistics software SPSS 20.0 for Windows was used to calculate the mean and standard deviation and conduct paired sample *t*-test. The result revealed:
The most common consumption seafood by mistake in Taiwan Seafood Guide “SAY NO” criterion is Cuttlefish which usually caught by methods that destroy marine habitats. Slow fish movement curriculum map significantly impacted students’ judgments on selection environment-friendly of seafood consumption ($t = -46.229$, $p < .001$) After taking the course of Slow Fish Movement that students exhibited significantly increased understanding of marine conservation and sustainability ($t = -19.064$, $p < .001$).

Sustainable development is the core target of Global growth. Teaching SFM curriculum map to promote awareness of environmentally friendly seafood-purchasing methods can enable consumers to eat more

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healthily and ocean ecology to be protected, thereby helping ocean ecology to recover its bioenergy.

Keywords: Slow Fish Movement, Sustainability, Marine Conservation, Taiwan Seafood Guide, Sustainable Development Goals (SDGs)

Keywords: Slow Fish Movement, Sustainability, Marine Conservation, Taiwan Seafood Guide, Sustainable Development Goals (SDGs),

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Prototyping of the teachable moment presetation for recent earthquakes in Japan (2) ---The case of the 3 January 2019 Kumamoto earthquake (M5.1) on and improvement from the previous prototype---

*Reiji Kobayashi[1]

1. Graduate School of Science and Engineering, Kagoshima University

Several news topics can be a good sources of teaching materials. Relation between news and contents of textbooks can interest students.

The Incorporated Research Institutes for Seismology (IRIS) have provided us with slides of teachable moment presentation on recent earthquakes in the world. Teachable moment means a good opportunity for teaching. I sometimes use the presentation slides in my lectures. However, the IRIS does not create the slides on moderate magnitude earthquakes, which cause moderate damages.

Therefore, I plan to prepare teachable moment presentation for recent earthquakes in Japan. I discussed the preparation guidelines based on that of the Incorporated Research Institutes for Seismology.

The guidelines are that the presentation 1) is prepared for high school and university students in Japan learning geoscience, 2) is created on recent earthquakes occurred in Japan, which may appear in a front page of a newspaper, 3) can be interpreted in about 10 minutes, 4) contains information of hypocenter, magnitude, seismic intensities, damages, tectonic background, historic seismicity, focal mechanism solution, aftershock distribution, seismograms, and other event-specific information, 5) is uploaded within 12 hours after the earthquake, 6) is created in a few hours by using the template, 7) is a classroom-ready product that can be customized, 8) contains open information, which sources are clearly given in slides, and 9) contains only information which may be agreed by most seismologist.

I created a prototype presentation on the 2018 Hokkaido Eastern Iburi earthquake, and uploaded it on the webpage (http://reijikan.my.coocan.jp/RETMJ/retmj-index.html) (Kobayashi, 2018a, b). Kobayashi (2018b) also discussed issues on the contents and the future project system.

On 3 January 2019, a M5.1 earthquake in Kumamoto prefecture. The JMA seismic intensity scale is up to 6 lower. I also created the presentation. I modified expression of the geometry of the fault plane including roughly approximate extent of the fault plane, and adopted a movie on the propagation of the seismic waves created by the National Research Institute for Earth Science and Disaster Resilience (NIED).

I hope that such developments of teachable moment presentation on volcanic eruptions, typhoons, and so on, are carried out to increase number of students learning geoscience.

References

Kobayashi, R. (2018a): Prototyping of the teachable moment presentation for recent earthquakes in Japan ---The case of the 2018 Hokkaido Eastern Iburi earthquake---, the 2018 Fall Meeting of the Seismological Society of Japan, S25-P27 (no abstract because of the late-breaking session on the 2018 Hokkaido

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Eastern Iburi earthquake).

Kobayashi, R. (2018b): Development of teachable moment presentation for recent earthquakes in Japan, Reports of the Faculty of Science, Kagoshima University, 51, 43-51. (in Japanese with English abstract)

Keywords: teachable moment, the 3 January 2019 Kumamoto earthquake

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Development of web application for polarizing microscope observation

*Fumitoshi Morisato[1]

1. Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo

It is essential to handle actual natural phenomena and natural samples to cultivate the scientific view of nature through geoscience education. At the same time, from the viewpoint of assisting and promoting achievement of the purpose, good quality geoscience materials that anyone can access anytime, anywhere is also necessary. For example, rocks and minerals show various diversity, so to acquire these appraisal methods it is necessary to observe while comparing multiple samples. Among them, concerning the appraisal using a polarization microscope, the cost, and labor required to prepare microscopes and rock slices can be a barrier, especially in self-study. To solve this problem, the speaker has developed a web application that can interactively observe the observation of rocks and minerals by polarizing microscope (“SCOPin rock,” URL is https://microscope.fumipo-theta.com). At the present stage, I have implemented sample selection, rotation, and enlargement of the field of view, switching between open Nicol and cross Nicol, and displaying variable scale.

This application's unique attempt as a polarizing microscope simulator is to deal with various devices including smartphones and tablets and to reduce the amount of data transfer. First of all, you can use this application regardless of the machine as long as you install a modern browser (such as Google Chrome, Safari, and Microsoft Edge), and you can use it in the excellent layout according to the screen size of the device. Second, while maintaining the smooth rotation of the visual field image, the number of images required for one sample is limited to 12 to 24 images. As a result, when using JPEG images of 1280 ×1280 px, the data size is about 2 to 3.5 MB, and the number of requests to the server is only one.

I assume the following use cases for this application.

1. In class, teachers can project polarized microscope images on the screen if there is a projector.

2. In the class, all the students can view and operate the same rock slice picture at hand.

3. In the geological excursion, you can share rock slice photos at the time of guidance.

In the future, I would like to realize content expansion and response to various use cases by publishing the upload function of polarization microscope image data by users and providing private repository creation service of image data.

Keywords: polarizing microscope, Web application, teaching materials

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Link to SCOPin rock

https://microscope.fumipo-theta.com

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Usage and Utilization of 3D display function on GSI Maps

*Ryoichi Kojiroi[1]

1. Geospatial Information Authority of Japan

GSI Maps which is a web map system operated by the Geospatial Information Authority of Japan (GSI), have a 3D display function, the so-called GSI Maps 3D. With the GSI Maps 3D, it is possible to visually grasp various topographies. The GSI Maps 3D can be used by Internet browsers, and it is also supported in smartphones. So the GSI Maps 3D will be useful for teaching material development. To create teaching materials, we encourage to make and enjoy various virtual terrain with the GSI Maps 3D.

First of all in my presentation, I will touch on how to use the GSI Maps 3D. In the latter part of my presentation, I will introduce examples of the topographical representation in 3D. I would like to take up as many things as possible, such as volcanic landform, rock-controlled landform, terrace, fault topography.

GSI Maps can represent various topographies in various ways, and new functions are added as needed. I will continue to consider useful examples for Geoscience education.

Keywords: GSI Maps, topography, 3D, Geoscience education, teaching materials

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Bringing field- and laboratory work into the classroom by using online modules in the edX platform

*Alejandra Quintanilla-Terminel[1], Matej Pec[1], Oliver Jagoutz[1]

1. Massachusetts Institute of Technology

We present two projects that aim at enhancing geoscience education in the classroom through the use of online modules in the edX platform. “Deform the earth” and “Virtual field trip” are two online modules that the department of Earth, Planetary, and Atmospheric sciences is developing in collaboration with MITx . These two modules will be used residentially at MIT, and by being freely accessible through the edX platform, also aim at expanding access to geoscience education worldwide. Each module addresses different challenges in geoscience education. How to teach laboratory skills in the classroom, particularly in a field that is both dangerous and difficult to access? How to teach field skills in a dynamic and effective way and how to make sure the students make the most out of their field experience?

Experimental rock deformation studies allow us to acquire data by measuring mechanical properties of rocks and minerals under a broad range of conditions. This data is essential for geodynamical models and tectonic interpretations. However, because the experimental protocols are difficult to explain in a classroom, and only few rock deformation laboratories exist world-wide, students overlook this component of Earth Sciences and often lack the knowledge to critically evaluate experimental results. Through “Deform the Earth” we want to introduce students to experimental rock deformation. An online module will allow us to both build and assess an experimentalist skill-set without ever needing to enter a real laboratory. The module is built on how-to videos explaining each step in the experimental procedure and analytical explanations of the data analysis. This module will allow us to experiment on ideal methods on how to teach a skill-set by scaffolding the experience for students. In addition, we plan to use pre- and post-testing to find out the most common misconceptions and worked and faded examples to teach how to interpret experimental data. The module will be freely accessible online and could be used by teaching institutions that do not have access to experimental rock deformation facilities.

An essential part of the geology training is learning how to make reliable field observations. This skill, however, is extremely difficult to teach in a traditional classroom setting. It is usually taught through field trips and it is a fundamental part of the curriculum that motivates and excites students into pursuing further studies in geology and earth sciences in general. In introductory classes, students are still learning to distinguish important characteristics in outcrops and may not be able to make important connections during the field trip. “Virtual field trip” aims at recreating the learning experience of the Introduction to geology class in the edX platform. It will be used residentially to provide the students access to the information learned in the field at different stages of the semester-long class, and allow them to consolidate their learning by strengthening connections between concepts they learned in the field and in the classroom. We plan to use pre- and post-testing and compare them with previous runs of the class that did not have access to the online module in order to evaluate its effectivity. The broader audience will benefit from a curated field experience that can be replicated by going to the sites.

Keywords: online learning, field trip, laboratory skills, blended learning

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[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_9

[M-IS01] Environmental, socio-economic and climatic changes in Northern Eurasia

convener:Pavel Groisman(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA), Shamil Maksyutov(National Institute for Environmental Studies), Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS), Dmitry A Streletskiy(George Washington University)

We invite presentations on the biogeochemical cycles, the surface energy budget and water cycle, and climate and ecosystem interactions in Northern Eurasia (land-cover and land-use change, atmospheric aerosols, soil, and permafrost changes that affect and are being affected by climate and ecosystem change), human dimension, and tools to address the Northern Eurasia studies. In environmental studies, our Session foci are on the carbon cycle of Northern Eurasia and on the permafrost changes in Siberia, Asian Mountains, and the Arctic coastal regions.
In the regional water cycle studies, our Session foci are on the changing distribution of precipitation intensity, frequency, especially, in the cold/shoulder season transition periods when surface air temperature is close to 0 deg.C, and on the pattern and seasonal cycle changes of runoff.
In the human dimension studies, our Session foci are on assessments of impact of the ongoing environmental changes in Northern Eurasia on the human well-being and on mitigation strategies development in response to harmful consequences of these changes
The particular foci of this Session will be the studies of changes that impacts regional sustainable development in the Dry Latitudinal Belt of Northern Eurasia that expands through the continent from Pannonian Steppes in the west to the drylands of northern China in the east.
We invite also early career scientists associated with (or interested in) the Northern Eurasia Earth Science Partnership Initiative and its continuation, Northern Eurasia Future Initiative (http://nefi-neespi.org/NEFI-WhitePaper.pdf).

Conveners:
Pavel Groisman, NC State University, USA (pasha.groisman@noaa.gov)
Shamil Maksyutov, National Institute for Environmental JAPAN (shamil@nies.go.jp)
Evgeny Gordov, Siberian Center for Environmental Research and Training, RUSSIA (gordov@scert.ru)
Yizhao Chen, Nanjing Forestry University, CHINA (chenyzvest@gmail.com)

[MIS01-P01] Effects of clear-cutting on carbon dioxide fluxes in a boreal forest ecosystem - results of numerical experiments with a three-dimensional turbulent exchange model

Yulia Mukhartova[3], Maria Dyachenko[3], Polina Mangura[3], Alexander Krupenko[3], *Alexander Olchev[1,2] (1.Faculty of Geography, Lomonosov Moscow State University, 2.A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, 3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P02] Retrieving the forest species composition from remote sensing data using a three-dimensional radiative transfer model

*Alexander Olchev[1,2], Natalia Levashova[3], Dmitry Lukyanenko[3] (1.Faculty of Geography, Lomonosov Moscow State University , 2.Severtsov Institute of Ecology and Evolution, Russian Academy of Science, 3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P03] Satellite-derived Burned Area for Siberia (1979 – 2000)

*Amber Jeanine Soja[1], Brian J. Stocks[2], Stefano Potter[3], Brendan Rogers[3], Donald R. Cahoon[4], Natasha Jurko[5], Susan G. Conard[6], William 'Bill' deGroot[5], Nadezhda Tchebakova[7] (1.National Iinstitute of Aerospace / NASA Langley Research Center, 2.B.J. Stocks Wildfire Investigations Ltd., 3.Woods Hole Research Center , 4.Terra Systems Research, 5.Canadian Forest Service/Service canadien des forêts, 6.George Mason University,Fairfax, VA, 7.Sukachev Institute of Forestry, Siberian Branch of the Russian Academy of Sciences)

[MIS01-P04] Analysis and prediction of hazardous hydrometeorological phenomena in the coastal areas of the Arctic

*Irina Repina[1,2] (1.A.M.Obukhov Institute of Atmospheric Physics RAS, 2.Lomonosov Moscow State University)

[MIS01-P05] **Recent baric and climatic conditions over East Europe with a focus on Belarus**

*Irina Danilovich[1], Vladimir Loginov[1], Pavel Groisman[2] (1. Institute for Nature Management National Academy of Science, Minsk, Belarus, 2. NC State University at NOAA National Centers for Environmental Information, Asheville, USA)

[MIS01-P06] **Assessment of climatic and environmental conditions along the track of projected Kyzyl-Kuragino railway line (the Western Sayan Mountains)**

★Invited Papers

*Aleksandra Alekseevna Mikheeva[1], Margarita Syromyatina[1], Yurii Kurochkin[1] (1.Institute of Earth Sciences, Saint Petersburg State University, Russia)

[MIS01-P07] **Assessment of interlinkages among industrialization, climate change, and forest fire activity: Thematic study of the Republic of Sakha (Yakutia), Russia**

*Kiunnei Kirillina[1], Wanglin Yan[1] (1.Graduate School of Media and Governance, Keio University SFC)

[MIS01-P08] Quantitative Evaluation of Winter Daily Precipitation over Northern Japan

*Minami Masuda[1], Akiyo Yatagai[1], Toshiyuki Nakaegawa[2], Kenji Kamiguchi[3] (1.Graduate School of Science and Technology, Hirosaki University, 2.Meteorological Research Institute/Japan Meteorological Agency, 3.Japan Meteorological Agency)

[MIS01-P09] Seasonal variation of wetland carbon dioxide and methane fluxes measured by automatic chambers at the Bakchar bog, West Siberia

*Shamil Maksyutov[1], Alexandre Fofonov[2], Denis Davydov[2], Oleg Krasnov[2], Tadanobu Nakayama[1], Mikhail Glagolev[3] (1.National Institute for Environmental Studies, 2.V.E. Zuev Institute of Atmospheric Optics, 3.M.V. Lomonosov Moscow State University)

[MIS01-P10] Climatic distances between origin and labor locations for migrants in a changing climate in Siberia by the end of the 21st century

*Elena I. Parfenova[1], Nadezhda M. Tchebakova[1] (1.V.N.Sukachev Institute of Forest SB RAS, FRC SB RAS)

Effects of clear-cutting on carbon dioxide fluxes in a boreal forest ecosystem - results of numerical experiments with a three-dimensional turbulent exchange model

Yulia Mukhartova[3], Maria Dyachenko[3], Polina Mangura[3], Alexander Krupenko[3], *Alexander Olchev[1,2]

1. Faculty of Geography, Lomonosov Moscow State University, 2. A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, 3. Faculty of Physics, Lomonosov Moscow State University

To estimate the possible effects of clear-cutting on the air flow disturbances within the atmospheric surface layer as well as on the spatial patterns of vertical carbon dioxide (CO2) fluxes and horizontal advection terms within and around the clear-cut area a process-based three-dimensional (3D) hydrodynamic momentum, energy and CO2 exchange model was developed. Clear-cutting is one of the most widespread logging practice, which can substantially transform the energy, water vapor and CO2 exchange between forest ecosystems and atmosphere and affect the climate system at multiple scales. Developed 3D hydrodynamic model is based on a 1.5-order closure scheme and uses a system of averaged Navier-Stokes and continuity equations for the mean wind speed components, as well as the reaction-advection-diffusion equation for CO2 transfer within the atmospheric surface layer (Mukhartova et al. 2015). The model applies Reynolds's decomposition and expresses the wind speed and concentrations of CO2 as sums of their mean values and deviations. The 1.5-closure scheme assumes that the turbulent fluxes can be expressed using the turbulent exchange coefficients (that depend on turbulent kinetic energy and its dissipation rate) and the gradients of corresponding functions (wind speed components and CO2 concentrations).
The clear-cut area selected for the study is situated in the south-western part of Valdai Hills in European Russia. The area of the clear-cut is about 4.5 ha and it is surrounded by a mixed forest stand represented mainly by Norway spruce, White birch and Eurasian aspen species with tree heights ranged between 18 and 22 m (Mamkin et al. 2016, 2019). The vegetation at the clear-cut area is mainly represented by herbaceous species and a small number of juvenile aspen trees.
Results of numerical experiments with the developed 3D model showed that clear-cutting has significant effect on spatial distributions of wind speed components as well as atmospheric momentum and CO2 fluxes. Spatial flux heterogeneity is also enhanced by complex shape of the clear-cut boundary. The largest effect of the clear-cut on the air flows is mainly appeared along the windward forest edge whereas at the leeward forest edge this effect is less pronounced. The leeward part of the clear-cut is characterized by prevailed downward air flows (with negative values of vertical wind component) whereas the upward air flows (with prevailed positive values of vertical wind component) are appeared at its windward part. It is very important to point out that the horizontal gradients of vertical and horizontal wind velocities at the lowest part of the atmospheric surface layer (up to the height 3-4 m above the ground surface) as well as horizontal turbulent and non-turbulent CO2 advection terms in the central part of the clear-cut is relatively small that can be used as important criteria indicating sufficient reestablishing of the air flow in this part of the clear-cut after its disturbance at the leeward forest edge.

Reference

Mamkin V., Kurbatova J., Avilov V., Mukhartova Yu, Krupenko A., Ivanov D., Levashova N., Olchev A. Changes in net ecosystem exchange of CO2, latent and sensible heat fluxes in a recently clear-cut spruce forest in western Russia: results from an experimental and modeling analysis. 2016. Environmental

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Research Letters. 11(12). 125012
Mamkin V., Kurbatova J., Avilov V., Ivanov D., Kuricheva O., Varlagin A., Yaseneva I., Olchev A. 2019 Energy and CO2 exchange in an undisturbed spruce forest and clear-cut in the Southern Taiga. Agricultural and Forest Meteorology, 265, 252-268
Mukhartova Yu. V., Levashova N. T., Olchev A. V., Shapkina N. E. 2015 Application of a 2D model for describing the turbulent transfer of CO2 in a spatially heterogeneous vegetation cover. Moscow University Physics Bulletin 70(1), 14-21

Keywords: turbulent exchange model, clear-cut, momentum fluxes, CO2 fluxes

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Retrieving the forest species composition from remote sensing data using a three-dimensional radiative transfer model

*Alexander Olchev[1,2], Natalia Levashova[3], Dmitry Lukyanenko[3]

1. Faculty of Geography, Lomonosov Moscow State University , 2. Severtsov Institute of Ecology and Evolution, Russian Academy of Science, 3. Faculty of Physics, Lomonosov Moscow State University

A three-dimensional model was developed to derive the reflection, absorption and transmission of photosynthetically active radiation (PAR) by a non-uniform forest canopy with a multi-species structure (Levashova et al., 2018). The model algorithm describing solar radiation transfer through a forest canopy considers direct and diffuse radiation penetrating through gaps in the canopy, transmitted by leaves and reflected from leaves, bark and soil surface. To estimate the canopy the reflection, absorption and transmission the model uses external data about 3D structure of each tree species in the forest stand, about the spectral properties of photosynthesizing and non-photosynthesizing parts of the different trees species, and about spectral reflectance of soil surface. Moreover it uses also information about incoming solar radiation, sun elevation, the ratio of incoming direct and diffuse solar radiation, and surface topography. The model is based on steady-state transport equations initially suggested by Ross (Ross, 1981) and further developed and described by Myneni and Knyazikhin (Myneni et al., 1990; Knyazikhin et al., 2005). Calculation of the direct solar radiation fluxes within the canopy is based on estimation of the probability that a ray of light passing through the foliage reaches a given location within the canopy without interception. Diffuse solar radiation is calculated taking into account both diffuse solar radiation from the sky penetrating through foliage gaps and direct and diffuse radiation scattered by canopy foliage and woody components. The numerical scheme for solving the integro-differential equations is based on the discrete ordinates method.
The model was used to describe the spatial patterns of solar radiation reflection and transmission by non-uniform mixed forest canopy and to develop an algorithm that allows to retrieve the proportion of different tree species in a mixed forest stand from measured canopy reflection coefficients for blue, green, red and near-infrared spectral bands (obtained from e.g. the Landsat satellite imagery). This approach allowed us to quantify the proportion of different tree species (both coniferous and deciduous) in a forest stand in case if their spectral reflection properties of the leaves are not the same. The accuracy of assessing the proportion of vegetation species using this method depended on the number of reflection measurements under various solar conditions (e.g. different sun elevations) that can reached by several measurements during the growing seasons. An increase of the input data volume (determined by the number of the measurements) resulted in higher accuracies for prediction of the proportions of different tree species.

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Netherlands, 1981, 390 p.

Keywords: radiative transfer, three-dimensional model, mixed forest, canopy reflection, inverse problem

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Satellite-derived Burned Area for Siberia (1979 –2000)

*Amber Jeanine Soja[1], Brian J. Stocks[2], Stefano Potter[3], Brendan Rogers[3], Donald R. Cahoon[4], Natasha Jurko[5], Susan G. Conard[6], William 'Bill' deGroot[5], Nadezhda Tchebakova[7]

1. National Iinstitute of Aerospace / NASA Langley Research Center, 2. B.J. Stocks Wildfire Investigations Ltd., 3. Woods Hole Research Center , 4. Terra Systems Research, 5. Canadian Forest Service/Service canadien des forêts, 6. George Mason University,Fairfax, VA, 7. Sukachev Institute of Forestry, Siberian Branch of the Russian Academy of Sciences

Siberia is a distinct and crucial region because it has the physical size necessary to effect regional and global climate. The circumboreal zone contains the largest stock of terrestrial carbon on Earth, and Russia holds roughly two-thirds of that carbon pool. Fire is the primary natural disturbance in boreal forest, which acts to cycle carbon and maintain ecosystem diversity in sync with the climate. Under current climate change scenarios, the Russian boreal is expected to experience temperature increases that exceed the global mean. We have developed a long-term burned area database that will enable novel analyses on the multi-decadal time scale that is ultimately required for robust assessments, including those focused on carbon cycling, fire emissions, and importantly the links between fire regimes, fire weather, ecosystems, and climate.

In this presentation, we present a long-term burned area database that has been developed using Advanced Very High Resolution Radiometer (AVHRR) Global Area Coverage (GAC) data from 1979-2000. Burned area has been verified using Total Ozone Mapping Spectrometer data and validated using available Landsat imagery (160 scenes thus far representing 5.6 Mha of burned area, 219 fire events, and 11% of the total area burned in the AVHRR database). Visually the burned scar data compare well. Validation is in ongoing, though initial analyses show an intersection of 42% with commission and omission errors of 31% and 25%, respectively. Most commission and omission errors are related to spatial inconsistencies using imagery with significantly different spatial resolutions. Of the fire events missed by AVHRR (i.e., omissions), 86% are related to fires <10,000 ha (~ 6 AVHRR pixels) and 44% are related to fires <3,000ha (~ 2 AVHRR pixels). Total burned area compares well, with the AVHRR database under-representing burned area by 10% compared to the Landsat data analyzed. Correlation in burned scar area between the AVHRR and Landsat data is 0.98 for all fires and 0.68 for fires that are < 0.1 Mha.

Keywords: Wildland Fire, Remote Sensing, Biomass Burning, Russia

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Analysis and prediction of hazardous hydrometeorological phenomena in the coastal areas of the Arctic

*Irina Repina[1,2]

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Currently, the Arctic is attracting increased attention not only as a region with the most noticeable climate change, but also as a world mineral storage, whose development prospects are being actively discussed. For Russia, which owns the bulk of the Arctic shelf, the Arctic is also a promising trade and transport artery, as in recent decades new opportunities for using the Northern Sea Route have been discovered. But climate change can lead to less favorable consequences. The increase in the ice-free sea surface enhances the role of wind waves in the Arctic basin, which threatens platforms for the extraction of hydrocarbons on the continental shelf, vessels navigating the Northern Sea Route or its sections, as well as onshore structures, including by increasing the rate of erosion shore. Reducing the duration of the ice season activates the dynamics of ice, increasing its hummocking, and, as a result, the effect of drifting formations drifting to the ice in the ice fields increases. The development of important economic sectors in the difficult climatic conditions of the Arctic is impossible without the development of reliable systems for forecasting regional changes in weather and climate. The main objective of the work is to analyze changes in wind-wave conditions and mesoscale atmospheric processes in the coastal regions of the Russian Arctic in recent decades and forecast their dynamics under conditions of a decrease in the ice extent of the Arctic Ocean. Unique archives of satellite and hydrometeorological data, reanalysis data, climatic, regional and wind-wave models are used. The main goal of the work is to improve the accuracy of regional forecasts of hazardous hydrometeorological phenomena in the polar regions based on the development of integrated monitoring technology for mesoscale atmospheric processes in the coastal zones of the Arctic seas of the Russian Federation based on a joint analysis of ground and satellite observations and mathematical modeling results. Most of the work's tasks - namely, the development of forecasting systems for leeward storms, mesoscale cyclones, assessment of the risks of their occurrence in the context of modern climate changes, are being solved for the first time.Currently, the Arctic is attracting increased attention not only as a region with the most noticeable climate change, but also as a world mineral storage, whose development prospects are being actively discussed. For Russia, which owns the bulk of the Arctic shelf, the Arctic is also a promising trade and transport artery, as in recent decades new opportunities for using the Northern Sea Route have been discovered.
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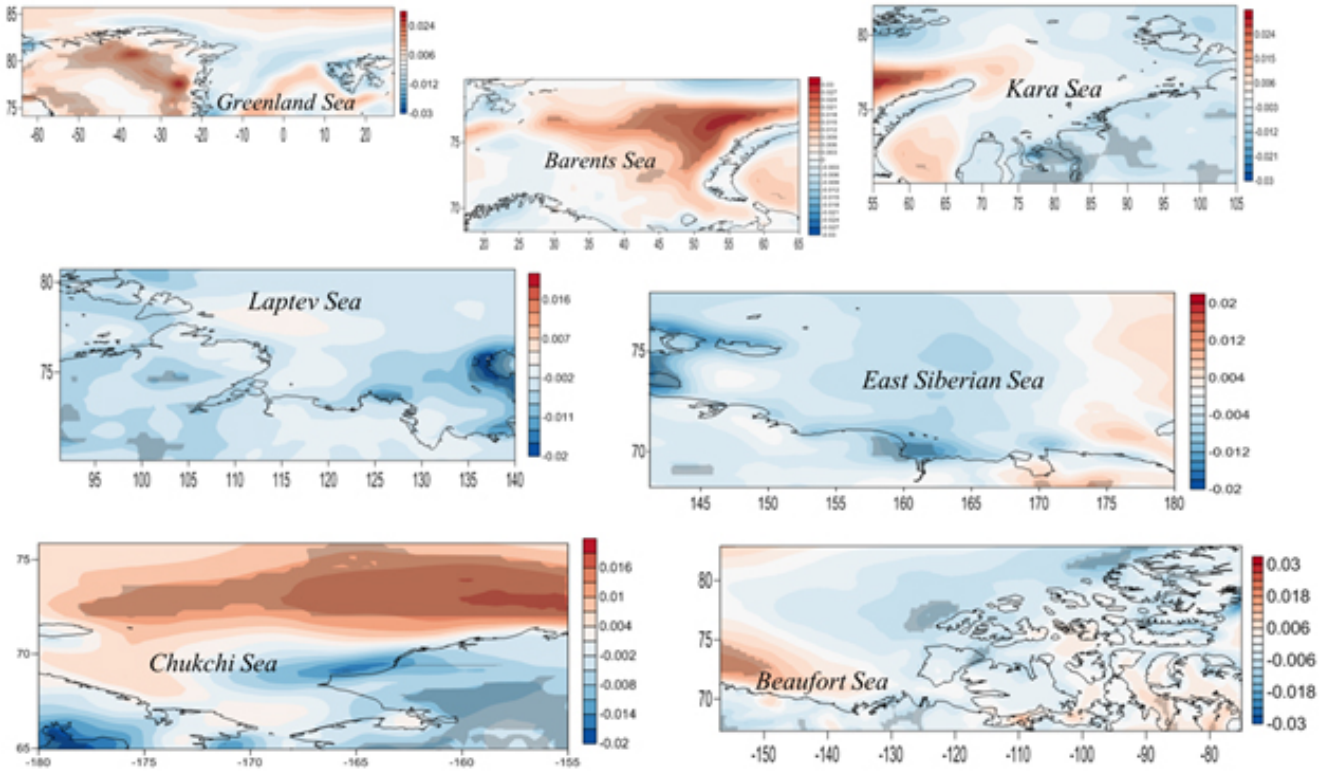
The figure shows the linear trend of the average for December-February wind speed (m / s / year) in different regions of the Arctic according to the CFSR data from 1979 to 2017. Gray indicates significant trends.

Keywords: Arctic climate, wind-wave-ice interaction, polar low



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Recent baric and climatic conditions over East Europe with a focus on Belarus

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The global and regional climate changes are the object of intent monitoring and research works. The results of climatic investigations are highly demanded and taken into account in projecting of any kinds of economic and social activities. At the same time the reasons of climate changes still remain as a point of scientific discussion. Despite the heightened attention to the anthropogenic contribution to the climate change, the natural factors still lead in the climatic system fluctuations. In this connection the aim of the present study is an analysis of current peculiarities of the atmospheric circulation as a main natural climatic driver, estimation of the prevailing cyclonic passes over East Europe region and its climatology.

The hypothesis of the research work is that climatic changes observed in the study region in the recent decades (increase of air temperature, especially in winter season, regional changes of the moistening pattern, number and spatial distribution of extreme events) are caused by changes in the frequency of cyclones of different origin which led to various hydrometeorological conditions on their passes. According to the pattern of cyclones movement over the Atlantic-European region, we analyzed cyclonic activity by approaching cyclone selection in groups by their origin: (a) cyclones originated in the North Atlantic and sampled by two sub-groups: the West (with zonal west-east pass from Atlantic to the continent) and the Scandinavian (with meridian pass from the Scandinavia to the south); (b) cyclones that originate in the Mediterranean Sea, the Balkan Peninsula, and the Black Sea and are moving in the northward direction. The frequency of occurrence, radius, duration, and atmospheric pressure in the cyclone center (cyclone depth) have been studied for all types of cyclones.

The input information for the study is presented as two data-sets of cyclone tracks derived with the algorithms developed by different groups of authors: (1) the P.P. Shirshov Institute of Oceanology of the Russian Academy of Sciences and (2) the A.M. Obukhov Institute of Atmospheric Physics of the Russian Academy of Sciences. Both algorithms were applied to the ECMWF Era-Interim reanalysis. The study period is 1979-2016 (37 years). The cyclonic data-sets presented as coordinates and sea level pressure in the cyclone center during their life. The correspondent meteorological phenomena are used to investigate the long-term climatological anomalies in the study region such as invasions of warm and cold air masses, severe droughts, intensive precipitation, etc.

In our previous study (Partasenok *et al* 2014), we established some peculiarities of cyclone tracks change in the Atlantic-European region in winter season and in this connection the streamflow freshet formation in Belarus. The main feature of the study was an increase of the West cyclones number in the Atlantic-European region and detection the third sub-group of the Atlantic cyclones named the North cyclones. The increase this type of cyclones and its shift to the northward led to the precipitation growth in the northern part of Belarus in winter and formation the special hydrometeorological conditions for smaller than average snow-melting floods in the country during recent decades. The present study is a continuation of this research work with spreading calculations to all seasons of the year and emphasizing on the long-living climatological anomalies and extreme events connected with cyclones of the different origin.

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Reference: Partasenok (Danilovich) I.S., P. Ya. Groisman, R.S. Chekan, and V. I. Melnik, 2014: Winter cyclone frequency and following freshet streamflow formation on the rivers in Belarus. *Environ. Res. Lett.*, **9,** 09005 (13 pp). doi:10.1088/1748-9326/9/9/095005 *Environ. Res. Lett.* **9** (2014) 109602 (2 pp) doi:10.1088/1748-9326/9/10/109602

Keywords: East Europe, regional climatic change, regional changes in atmospheric circulation, Belarus

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Assessment of climatic and environmental conditions along the track of projected Kyzyl-Kuragino railway line (the Western Sayan Mountains)

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Currently there is a large investment project of the Kyzyl-Kuragino railway line construction mostly along the mountainous territory of Tuva and Krasnoyarsk Krai. The main relevance of the project is the possibility of more active involvement of the Tuva coal complex in commercial operation, which means economic development of the region. At the same time it is planned also to extend the road to Mongolia with the prospect to reach China thereby take into account international interests.

Despite the positive economic and social effects there are significant difficulties in the realization of the project due to the natural and climatic conditions. The projected railway track is mostly located in the Western Sayan Mountains and is characterized by complex environmental conditions, in particular geological and geomorphological, as well as extreme climatic characteristics, permafrost etc. The main goal of this research was to conduct an independent scientific expertise of assessment of the environmental conditions during the implementation of one the largest transport projects in Siberian region.

The natural conditions were assessed according to the following indicators: extreme values of air temperature and precipitation, strong winds, snow cover thickness, avalanche danger, seismicity and some slope processes. Analysis was made using various map documents, statistical data, results of expert interviews with the representatives of regional ministries of transport and ministries of economic development, universities and research institutes. For the analysis of extreme climatic characteristics data from weather stations of the study region were used. The entire area of projected road construction was divided into several sections, where it is necessary to take into account certain parameters mainly extreme natural phenomena. As a result the assessment of the potential natural risks during the construction and further operation of the railway was made.

Keywords: natural conditions, railway line construction, mountains, Tuva and Krasnoyarsk Krai

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Assessment of interlinkages among industrialization, climate change, and forest fire activity: Thematic study of the Republic of Sakha (Yakutia), Russia

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Forest fires play a critical role in shaping the ecosystem and atmospheric patterns. In turn, fire regimes are highly influenced by climate and human activities. Natural cycles, human activities like land-use changes and fire exclusion, and human-caused climate change can also influence the likelihood of fires. This study aimed to identify the causes underlying the increase of fire activity in one of the most fire-hazardous regions of Russia, the Republic of Sakha (Yakutia). The forest in this republic is performing the important function of permafrost protection. Deforestation might cause a catastrophic permafrost degradation, as the decrease of forests there mainly occurs due to fires.

To understand the patterns of historical fire activity, we analyzed the past history of fire events in the Sakha Republic through a newly developed approach for historical fire regimes characterization. Then, to identify the exact cause of intensification of fire activity was constructed an analytical approach for the assessment of interlinkages among industrialization, climate change, and forest fire activity. The study found that the main contributor to the increased historical fire activity in the republic was climate warming documented there since the 1960s, especially in spring season, which affected the overall duration of the fire season. As one main cause of recent expansion of fires, this research identified as significant the socioeconomic and land use changes undergone on the territory of the republic since the 2000s, which have resulted in extensive use of forest and forested land, and increased number of anthropogenic fires and related atmospheric changes.

Keywords: forest fires and climate change, land use changes, anthropogenic fires, GHG emissions

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Quantitative Evaluation of Winter Daily Precipitation over Northern Japan

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Snowfall is an important parameter for water resources. An accurate, quantitative evaluation is needed to clarify the impact of global warming on snowfall and vice versa. For that evaluation, a gridded precipitation data set based on rain-gauges is suitable, because rain-gauges measure precipitation directly. However, rain-gauge data include systematic biases due to interpolation and observation biases. For example, the long-term average, daily gridded precipitation data from APHRO_JP (P) underestimates by 30% the sum of evapotranspiration (E) and inflow (R) from dam catchments located in Northern Japan. We know this because if APHRO_JP was accurate, P should be equal to $R+E$ and it is not. It was reported that the annual mean precipitation of Japan was well simulated in the non-hydrostatic regional climate model (NHRCM, spatial resolutions 5 km/2 km) produced by the Meteorological Research Institute (MRI). From the above, we validated the interpolation bias of APHRO_JP using precipitation from the NHRCM to quantitatively evaluate winter precipitation over Northern Japan. The bias in the water balance from the dam catchments was reduced to 1% after adjusting for three systematic biases.

First, we validated and adjusted the interpolation bias. We created daily precipitation gridded data based on the distribution of the Automated Meteorological Data Acquisition System (AMeDAS) using hourly precipitation from the NHRCM (spatial distribution 2 km) and we compared it with precipitation from the NHRCM. We found that precipitation from the Mesh precipitation climatology which is used in APHRO_JP underestimated precipitation over mountain areas where rain-gauges were not set up. Because of this, APHRO_JP underestimated winter precipitation over mountain areas by approximately 3 mm/day. This daily precipitation bias over mountain areas was halved when we used climatology based on precipitation from the NHRCM instead of Mesh precipitation climatology.

Even with this adjustment, precipitation over mountain areas was still underestimated. This stemmed from the interpolation method used to predict rainfall, because the climatology indicate that the ratio of precipitation increases seasonally with elevation over mountain areas. This underestimation was controlled by an adjustment to the interpolation bias from the precipitation pattern detected by an Empirical Orthogonal Function (EOF) analysis.

On the basis of these validation results, we created daily precipitation gridded data based on the AMeDAS rain-gauge. We then applied the three adjustments from the climatology, precipitation pattern and precipitation undercatch and evaluated their contribution. We found that the annual precipitation over Japan was 2054 mm/year, which was an 18% increase on APHRO_JP. Furthermore, at the four dam catchments in Northern Japan, this adjusted precipitation explained 99% of the precipitation estimated by inflow from the dam catchments and evapotranspiration.

Finally, we measured the contribution of the systematic bias in winter precipitation in Northern Japan (138.5–141˚E, 36.8–38.8˚N). Precipitation was increased 11% by changing the climatology and increased 12% by adjusting for precipitation undercatch. The impact of the precipitation pattern adjustment was small. For extreme events, the adjustment effect was different. On average, in the four dam catchments,

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precipitation was increased 18% by the change of climatology 7% by adjustment for precipitation undercatch. However, these ratios were different at each dam, and in dams where the catchments were in high mountain regions, there was a much greater effect from a change in the climatology. Because there are few rain-gauges in high mountain regions, it important to change climatology used in APHRO_JP. Furthermore, our results indicate uncertainty in precipitation from internal variability when the precipitation pattern adjustment was not used. Our application of these adjustments to APHRO_JP reduced systematic bias and improved precipitation measurements.

Keywords: APHRO_JP, winter precipitation, water resource

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Seasonal variation of wetland carbon dioxide and methane fluxes measured by automatic chambers at the Bakchar bog, West Siberia

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1. National Institute for Environmental Studies, 2. V.E. Zuev Institute of Atmospheric Optics, 3. M.V. Lomonosov Moscow State University

Wetland CO_2 and CH_4 fluxes were observed at the Bakchar bog (N56˚, E82˚), West Siberia. Measurements were performed by two solar powered automated systems, each consisting of NDIR Li-820 CO_2 analyzer, an SnO_2-based methane sensor, six static chambers installed along transects, the air drying and distribution unit, and a datalogger. Observations were made during the May to October period in 2014 to 2017 at two types of open wetlands: mesotrophic open bog and patterned wetland with forested ridges, flat hollows and water pool. Each chamber is automatically opened and closed with pneumatic actuator. Water level is measured in the wetland and surrounding forest locations. Net uptake of CO_2 is observed from the beginning of June through the end of August with a maximum from mid-June through the end of July. Seasonal pattern of methane fluxes showed that CH_4 emission increases at the beginning of June, then weakens gradually in autumn. Seasonal variation of the emissions correlates well with the soil temperature at 5-10 cm depth. Carbon dioxide and methane fluxes correlate spatially; higher methane emissions are observed at wet mesotrophic locations with higher photosynthesis/respiration rates. Lower CH_4 emissions were observed on oligotrophic patterned wetland.

Keywords: methane emissions, wetland, Siberia, CO2 fluxes

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Climatic distances between origin and labor locations for migrants in a changing climate in Siberia by the end of the 21st century

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The goals of our work were to evaluate climatic distances between climates from which potential migrants originate and climates of various regions over Siberia for which they migrate; and evaluate Siberian regions from view points of comfort-discomfort for migrants in current and future climates by the end of the century. We have completed this research from the example of the Krasnoyarsk Territory that is located in the center of Siberia and stretches from the south to north at a distance 2,000 km. Statistics on migrations show that migrants arrive to the Krasnoyarsk Territory from the European Russia and far abroad: Northern Korea, China, Vietnam. We studied four large industrial regions of the Territory for labor migrations. We used two climate variables that reflect winter and summer conditions: mean January and July temperatures. In total, 30 cities were ordinated in the axes of the differences in these temperatures between migrants' origins and migration locations. To characterize the future climates by the end of the century we used January and July temperature departure means from the ensemble of twenty general circulation models from the CMIP5. Two scenarios were used to characterize the range of climate change: a mild RCP 2.6 and a sharp RCP 8.5 climate scenarios. In total, 12 portraits of potential labor migrations were outlined in current and future climates. The "null" point in each portrait showed conditions for the natives of a particular region and the distance from the null to a country of origin showed physiological and psychological discrepancy that migrants should overcome to live in new climate.

Keywords: migration, climate change, transfer function, Siberia, January and July temperatures

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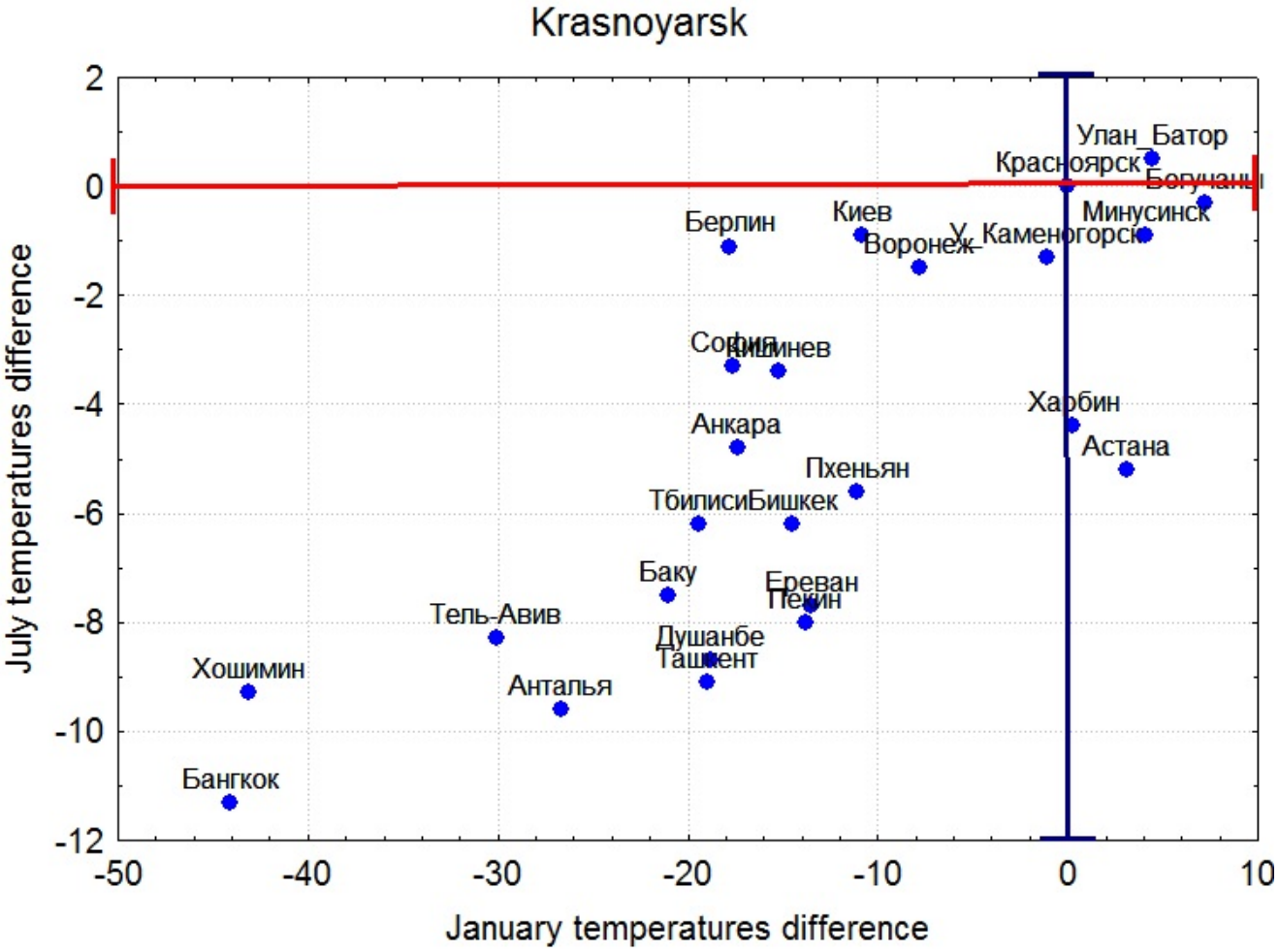

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[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_40

[M-IS01] Environmental, socio-economic and climatic changes in Northern Eurasia

convener:Pavel Groisman(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA), Shamil Maksyutov(National Institute for Environmental Studies), Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS), Dmitry A Streletskiy(George Washington University)

We invite presentations on the biogeochemical cycles, the surface energy budget and water cycle, and climate and ecosystem interactions in Northern Eurasia (land-cover and land-use change, atmospheric aerosols, soil, and permafrost changes that affect and are being affected by climate and ecosystem change), human dimension, and tools to address the Northern Eurasia studies. In environmental studies, our Session foci are on the carbon cycle of Northern Eurasia and on the permafrost changes in Siberia, Asian Mountains, and the Arctic coastal regions.
In the regional water cycle studies, our Session foci are on the changing distribution of precipitation intensity, frequency, especially, in the cold/shoulder season transition periods when surface air temperature is close to 0 deg.C, and on the pattern and seasonal cycle changes of runoff.
In the human dimension studies, our Session foci are on assessments of impact of the ongoing environmental changes in Northern Eurasia on the human well-being and on mitigation strategies development in response to harmful consequences of these changes
The particular foci of this Session will be the studies of changes that impacts regional sustainable development in the Dry Latitudinal Belt of Northern Eurasia that expands through the continent from Pannonian Steppes in the west to the drylands of northern China in the east.
We invite also early career scientists associated with (or interested in) the Northern Eurasia Earth Science Partnership Initiative and its continuation, Northern Eurasia Future Initiative (http://nefi-neespi.org/NEFI-WhitePaper.pdf).

Conveners:
Pavel Groisman, NC State University, USA (pasha.groisman@noaa.gov)
Shamil Maksyutov, National Institute for Environmental JAPAN (shamil@nies.go.jp)
Evgeny Gordov, Siberian Center for Environmental Research and Training, RUSSIA (gordov@scert.ru)
Yizhao Chen, Nanjing Forestry University, CHINA (chenyzvest@gmail.com)

[MIS01-P01] Effects of clear-cutting on carbon dioxide fluxes in a boreal forest ecosystem - results of numerical experiments with a three-dimensional turbulent exchange model

Yulia Mukhartova[3], Maria Dyachenko[3], Polina Mangura[3], Alexander Krupenko[3], *Alexander Olchev[1,2] (1.Faculty of Geography, Lomonosov Moscow State University, 2.A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, 3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P02] Retrieving the forest species composition from remote sensing data using a three-dimensional radiative transfer model

*Alexander Olchev[1,2], Natalia Levashova[3], Dmitry Lukyanenko[3] (1.Faculty of Geography, Lomonosov Moscow State University , 2.Severtsov Institute of Ecology and Evolution, Russian Academy of Science, 3.Faculty of Physics, Lomonosov Moscow State University)

[MIS01-P03] Satellite-derived Burned Area for Siberia (1979 – 2000)

*Amber Jeanine Soja[1], Brian J. Stocks[2], Stefano Potter[3], Brendan Rogers[3], Donald R. Cahoon[4], Natasha Jurko[5], Susan G. Conard[6], William 'Bill' deGroot[5], Nadezhda Tchebakova[7] (1.National Iinstitute of Aerospace / NASA Langley Research Center, 2.B.J. Stocks Wildfire Investigations Ltd., 3.Woods Hole Research Center , 4.Terra Systems Research, 5.Canadian Forest Service/Service canadien des forêts, 6.George Mason University,Fairfax, VA, 7.Sukachev Institute of Forestry, Siberian Branch of the Russian Academy of Sciences)

[MIS01-P04] Analysis and prediction of hazardous hydrometeorological phenomena in the coastal areas of the Arctic

*Irina Repina[1,2] (1.A.M.Obukhov Institute of Atmospheric Physics RAS, 2.Lomonosov Moscow State University)

[MIS01-P05] **Recent baric and climatic conditions over East Europe with a focus on Belarus**

*Irina Danilovich[1], Vladimir Loginov[1], Pavel Groisman[2] (1. Institute for Nature Management National Academy of Science, Minsk, Belarus, 2. NC State University at NOAA National Centers for Environmental Information, Asheville, USA)

[MIS01-P06] **Assessment of climatic and environmental conditions along the track of projected Kyzyl-Kuragino railway line (the Western Sayan Mountains)**

★Invited Papers

*Aleksandra Alekseevna Mikheeva[1], Margarita Syromyatina[1], Yurii Kurochkin[1] (1.Institute of Earth Sciences, Saint Petersburg State University, Russia)

[MIS01-P07] **Assessment of interlinkages among industrialization, climate change, and forest fire activity: Thematic study of the Republic of Sakha (Yakutia), Russia**

*Kiunnei Kirillina[1], Wanglin Yan[1] (1.Graduate School of Media and Governance, Keio University SFC)

[MIS01-P08] Quantitative Evaluation of Winter Daily Precipitation over Northern Japan

*Minami Masuda[1], Akiyo Yatagai[1], Toshiyuki Nakaegawa[2], Kenji Kamiguchi[3] (1.Graduate School of Science and Technology, Hirosaki University, 2.Meteorological Research Institute/Japan Meteorological Agency, 3.Japan Meteorological Agency)

[MIS01-P09] Seasonal variation of wetland carbon dioxide and methane fluxes measured by automatic chambers at the Bakchar bog, West Siberia

*Shamil Maksyutov[1], Alexandre Fofonov[2], Denis Davydov[2], Oleg Krasnov[2], Tadanobu Nakayama[1], Mikhail Glagolev[3] (1.National Institute for Environmental Studies, 2.V.E. Zuev Institute of Atmospheric Optics, 3.M.V. Lomonosov Moscow State University)

[MIS01-P10] Climatic distances between origin and labor locations for migrants in a changing climate in Siberia by the end of the 21st century

*Elena I. Parfenova[1], Nadezhda M. Tchebakova[1] (1.V.N.Sukachev Institute of Forest SB RAS, FRC SB RAS)

Effects of clear-cutting on carbon dioxide fluxes in a boreal forest ecosystem - results of numerical experiments with a three-dimensional turbulent exchange model

Yulia Mukhartova[3], Maria Dyachenko[3], Polina Mangura[3], Alexander Krupenko[3], *Alexander Olchev[1,2]

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To estimate the possible effects of clear-cutting on the air flow disturbances within the atmospheric surface layer as well as on the spatial patterns of vertical carbon dioxide (CO2) fluxes and horizontal advection terms within and around the clear-cut area a process-based three-dimensional (3D) hydrodynamic momentum, energy and CO2 exchange model was developed. Clear-cutting is one of the most widespread logging practice, which can substantially transform the energy, water vapor and CO2 exchange between forest ecosystems and atmosphere and affect the climate system at multiple scales. Developed 3D hydrodynamic model is based on a 1.5-order closure scheme and uses a system of averaged Navier-Stokes and continuity equations for the mean wind speed components, as well as the reaction-advection-diffusion equation for CO2 transfer within the atmospheric surface layer (Mukhartova et al. 2015). The model applies Reynolds's decomposition and expresses the wind speed and concentrations of CO2 as sums of their mean values and deviations. The 1.5-closure scheme assumes that the turbulent fluxes can be expressed using the turbulent exchange coefficients (that depend on turbulent kinetic energy and its dissipation rate) and the gradients of corresponding functions (wind speed components and CO2 concentrations).
The clear-cut area selected for the study is situated in the south-western part of Valdai Hills in European Russia. The area of the clear-cut is about 4.5 ha and it is surrounded by a mixed forest stand represented mainly by Norway spruce, White birch and Eurasian aspen species with tree heights ranged between 18 and 22 m (Mamkin et al. 2016, 2019). The vegetation at the clear-cut area is mainly represented by herbaceous species and a small number of juvenile aspen trees.
Results of numerical experiments with the developed 3D model showed that clear-cutting has significant effect on spatial distributions of wind speed components as well as atmospheric momentum and CO2 fluxes. Spatial flux heterogeneity is also enhanced by complex shape of the clear-cut boundary. The largest effect of the clear-cut on the air flows is mainly appeared along the windward forest edge whereas at the leeward forest edge this effect is less pronounced. The leeward part of the clear-cut is characterized by prevailed downward air flows (with negative values of vertical wind component) whereas the upward air flows (with prevailed positive values of vertical wind component) are appeared at its windward part. It is very important to point out that the horizontal gradients of vertical and horizontal wind velocities at the lowest part of the atmospheric surface layer (up to the height 3-4 m above the ground surface) as well as horizontal turbulent and non-turbulent CO2 advection terms in the central part of the clear-cut is relatively small that can be used as important criteria indicating sufficient reestablishing of the air flow in this part of the clear-cut after its disturbance at the leeward forest edge.

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Keywords: turbulent exchange model, clear-cut, momentum fluxes, CO2 fluxes

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Retrieving the forest species composition from remote sensing data using a three-dimensional radiative transfer model

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A three-dimensional model was developed to derive the reflection, absorption and transmission of photosynthetically active radiation (PAR) by a non-uniform forest canopy with a multi-species structure (Levashova et al., 2018). The model algorithm describing solar radiation transfer through a forest canopy considers direct and diffuse radiation penetrating through gaps in the canopy, transmitted by leaves and reflected from leaves, bark and soil surface. To estimate the canopy the reflection, absorption and transmission the model uses external data about 3D structure of each tree species in the forest stand, about the spectral properties of photosynthesizing and non-photosynthesizing parts of the different trees species, and about spectral reflectance of soil surface. Moreover it uses also information about incoming solar radiation, sun elevation, the ratio of incoming direct and diffuse solar radiation, and surface topography. The model is based on steady-state transport equations initially suggested by Ross (Ross, 1981) and further developed and described by Myneni and Knyazikhin (Myneni et al., 1990; Knyazikhin et al., 2005). Calculation of the direct solar radiation fluxes within the canopy is based on estimation of the probability that a ray of light passing through the foliage reaches a given location within the canopy without interception. Diffuse solar radiation is calculated taking into account both diffuse solar radiation from the sky penetrating through foliage gaps and direct and diffuse radiation scattered by canopy foliage and woody components. The numerical scheme for solving the integro-differential equations is based on the discrete ordinates method.
The model was used to describe the spatial patterns of solar radiation reflection and transmission by non-uniform mixed forest canopy and to develop an algorithm that allows to retrieve the proportion of different tree species in a mixed forest stand from measured canopy reflection coefficients for blue, green, red and near-infrared spectral bands (obtained from e.g. the Landsat satellite imagery). This approach allowed us to quantify the proportion of different tree species (both coniferous and deciduous) in a forest stand in case if their spectral reflection properties of the leaves are not the same. The accuracy of assessing the proportion of vegetation species using this method depended on the number of reflection measurements under various solar conditions (e.g. different sun elevations) that can reached by several measurements during the growing seasons. An increase of the input data volume (determined by the number of the measurements) resulted in higher accuracies for prediction of the proportions of different tree species.

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Keywords: radiative transfer, three-dimensional model, mixed forest, canopy reflection, inverse problem

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Satellite-derived Burned Area for Siberia (1979 –2000)

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1. National Iinstitute of Aerospace / NASA Langley Research Center, 2. B.J. Stocks Wildfire Investigations Ltd., 3. Woods Hole Research Center , 4. Terra Systems Research, 5. Canadian Forest Service/Service canadien des forêts, 6. George Mason University,Fairfax, VA, 7. Sukachev Institute of Forestry, Siberian Branch of the Russian Academy of Sciences

Siberia is a distinct and crucial region because it has the physical size necessary to effect regional and global climate. The circumboreal zone contains the largest stock of terrestrial carbon on Earth, and Russia holds roughly two-thirds of that carbon pool. Fire is the primary natural disturbance in boreal forest, which acts to cycle carbon and maintain ecosystem diversity in sync with the climate. Under current climate change scenarios, the Russian boreal is expected to experience temperature increases that exceed the global mean. We have developed a long-term burned area database that will enable novel analyses on the multi-decadal time scale that is ultimately required for robust assessments, including those focused on carbon cycling, fire emissions, and importantly the links between fire regimes, fire weather, ecosystems, and climate.

In this presentation, we present a long-term burned area database that has been developed using Advanced Very High Resolution Radiometer (AVHRR) Global Area Coverage (GAC) data from 1979-2000. Burned area has been verified using Total Ozone Mapping Spectrometer data and validated using available Landsat imagery (160 scenes thus far representing 5.6 Mha of burned area, 219 fire events, and 11% of the total area burned in the AVHRR database). Visually the burned scar data compare well. Validation is in ongoing, though initial analyses show an intersection of 42% with commission and omission errors of 31% and 25%, respectively. Most commission and omission errors are related to spatial inconsistencies using imagery with significantly different spatial resolutions. Of the fire events missed by AVHRR (i.e., omissions), 86% are related to fires <10,000 ha (~ 6 AVHRR pixels) and 44% are related to fires <3,000ha (~ 2 AVHRR pixels). Total burned area compares well, with the AVHRR database under-representing burned area by 10% compared to the Landsat data analyzed. Correlation in burned scar area between the AVHRR and Landsat data is 0.98 for all fires and 0.68 for fires that are < 0.1 Mha.

Keywords: Wildland Fire, Remote Sensing, Biomass Burning, Russia

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Analysis and prediction of hazardous hydrometeorological phenomena in the coastal areas of the Arctic

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Currently, the Arctic is attracting increased attention not only as a region with the most noticeable climate change, but also as a world mineral storage, whose development prospects are being actively discussed. For Russia, which owns the bulk of the Arctic shelf, the Arctic is also a promising trade and transport artery, as in recent decades new opportunities for using the Northern Sea Route have been discovered. But climate change can lead to less favorable consequences. The increase in the ice-free sea surface enhances the role of wind waves in the Arctic basin, which threatens platforms for the extraction of hydrocarbons on the continental shelf, vessels navigating the Northern Sea Route or its sections, as well as onshore structures, including by increasing the rate of erosion shore. Reducing the duration of the ice season activates the dynamics of ice, increasing its hummocking, and, as a result, the effect of drifting formations drifting to the ice in the ice fields increases. The development of important economic sectors in the difficult climatic conditions of the Arctic is impossible without the development of reliable systems for forecasting regional changes in weather and climate. The main objective of the work is to analyze changes in wind-wave conditions and mesoscale atmospheric processes in the coastal regions of the Russian Arctic in recent decades and forecast their dynamics under conditions of a decrease in the ice extent of the Arctic Ocean. Unique archives of satellite and hydrometeorological data, reanalysis data, climatic, regional and wind-wave models are used. The main goal of the work is to improve the accuracy of regional forecasts of hazardous hydrometeorological phenomena in the polar regions based on the development of integrated monitoring technology for mesoscale atmospheric processes in the coastal zones of the Arctic seas of the Russian Federation based on a joint analysis of ground and satellite observations and mathematical modeling results. Most of the work's tasks - namely, the development of forecasting systems for leeward storms, mesoscale cyclones, assessment of the risks of their occurrence in the context of modern climate changes, are being solved for the first time.Currently, the Arctic is attracting increased attention not only as a region with the most noticeable climate change, but also as a world mineral storage, whose development prospects are being actively discussed. For Russia, which owns the bulk of the Arctic shelf, the Arctic is also a promising trade and transport artery, as in recent decades new opportunities for using the Northern Sea Route have been discovered.
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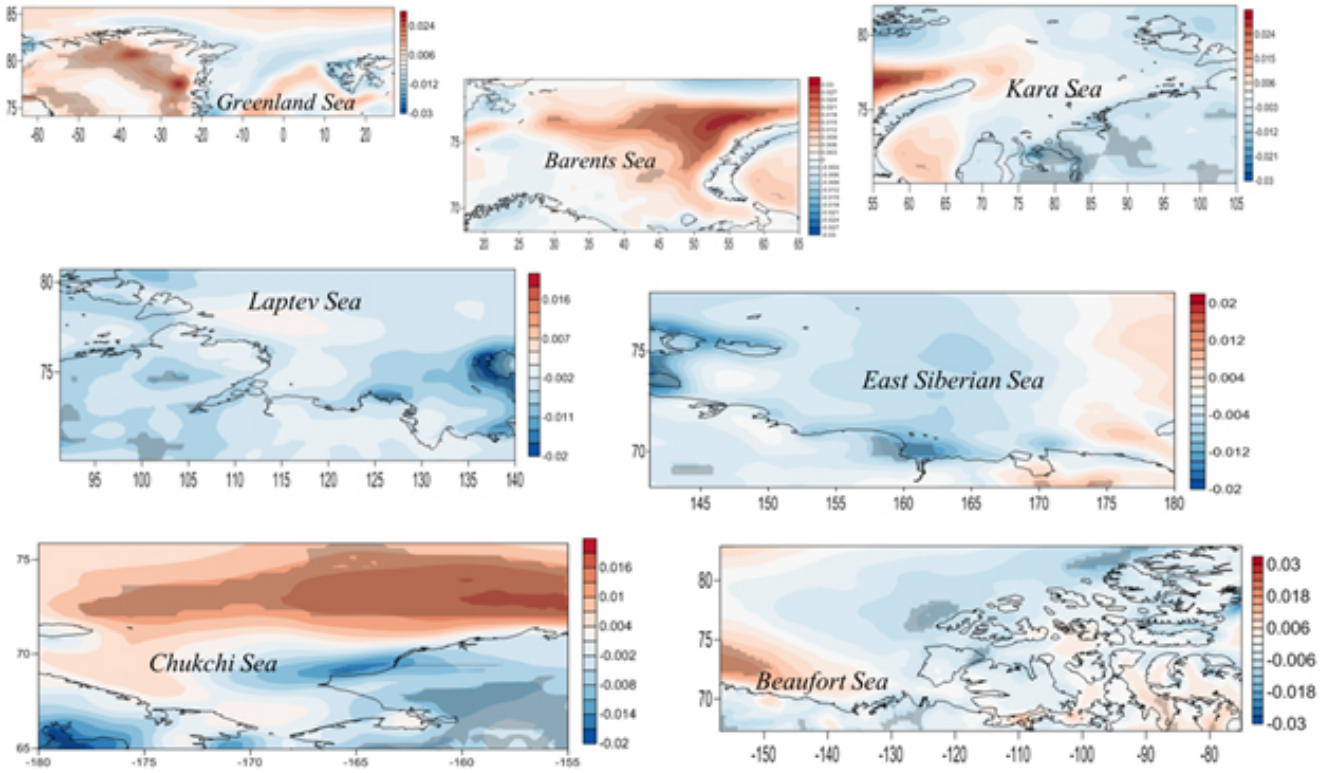
The figure shows the linear trend of the average for December-February wind speed (m / s / year) in different regions of the Arctic according to the CFSR data from 1979 to 2017. Gray indicates significant trends.

Keywords: Arctic climate, wind-wave-ice interaction, polar low



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Recent baric and climatic conditions over East Europe with a focus on Belarus

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The global and regional climate changes are the object of intent monitoring and research works. The results of climatic investigations are highly demanded and taken into account in projecting of any kinds of economic and social activities. At the same time the reasons of climate changes still remain as a point of scientific discussion. Despite the heightened attention to the anthropogenic contribution to the climate change, the natural factors still lead in the climatic system fluctuations. In this connection the aim of the present study is an analysis of current peculiarities of the atmospheric circulation as a main natural climatic driver, estimation of the prevailing cyclonic passes over East Europe region and its climatology.

The hypothesis of the research work is that climatic changes observed in the study region in the recent decades (increase of air temperature, especially in winter season, regional changes of the moistening pattern, number and spatial distribution of extreme events) are caused by changes in the frequency of cyclones of different origin which led to various hydrometeorological conditions on their passes. According to the pattern of cyclones movement over the Atlantic-European region, we analyzed cyclonic activity by approaching cyclone selection in groups by their origin: (a) cyclones originated in the North Atlantic and sampled by two sub-groups: the West (with zonal west-east pass from Atlantic to the continent) and the Scandinavian (with meridian pass from the Scandinavia to the south); (b) cyclones that originate in the Mediterranean Sea, the Balkan Peninsula, and the Black Sea and are moving in the northward direction. The frequency of occurrence, radius, duration, and atmospheric pressure in the cyclone center (cyclone depth) have been studied for all types of cyclones.

The input information for the study is presented as two data-sets of cyclone tracks derived with the algorithms developed by different groups of authors: (1) the P.P. Shirshov Institute of Oceanology of the Russian Academy of Sciences and (2) the A.M. Obukhov Institute of Atmospheric Physics of the Russian Academy of Sciences. Both algorithms were applied to the ECMWF Era-Interim reanalysis. The study period is 1979-2016 (37 years). The cyclonic data-sets presented as coordinates and sea level pressure in the cyclone center during their life. The correspondent meteorological phenomena are used to investigate the long-term climatological anomalies in the study region such as invasions of warm and cold air masses, severe droughts, intensive precipitation, etc.

In our previous study (Partasenok *et al* 2014), we established some peculiarities of cyclone tracks change in the Atlantic-European region in winter season and in this connection the streamflow freshet formation in Belarus. The main feature of the study was an increase of the West cyclones number in the Atlantic-European region and detection the third sub-group of the Atlantic cyclones named the North cyclones. The increase this type of cyclones and its shift to the northward led to the precipitation growth in the northern part of Belarus in winter and formation the special hydrometeorological conditions for smaller than average snow-melting floods in the country during recent decades. The present study is a continuation of this research work with spreading calculations to all seasons of the year and emphasizing on the long-living climatological anomalies and extreme events connected with cyclones of the different origin.

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Reference: Partasenok (Danilovich) I.S., P. Ya. Groisman, R.S. Chekan, and V. I. Melnik, 2014: Winter cyclone frequency and following freshet streamflow formation on the rivers in Belarus. *Environ. Res. Lett.*, **9,** 09005 (13 pp). doi:10.1088/1748-9326/9/9/095005 *Environ. Res. Lett.* **9** (2014) 109602 (2 pp) doi:10.1088/1748-9326/9/10/109602

Keywords: East Europe, regional climatic change, regional changes in atmospheric circulation, Belarus

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Assessment of climatic and environmental conditions along the track of projected Kyzyl-Kuragino railway line (the Western Sayan Mountains)

*Aleksandra Alekseevna Mikheeva[1], Margarita Syromyatina[1], Yurii Kurochkin[1]

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Currently there is a large investment project of the Kyzyl-Kuragino railway line construction mostly along the mountainous territory of Tuva and Krasnoyarsk Krai. The main relevance of the project is the possibility of more active involvement of the Tuva coal complex in commercial operation, which means economic development of the region. At the same time it is planned also to extend the road to Mongolia with the prospect to reach China thereby take into account international interests.

Despite the positive economic and social effects there are significant difficulties in the realization of the project due to the natural and climatic conditions. The projected railway track is mostly located in the Western Sayan Mountains and is characterized by complex environmental conditions, in particular geological and geomorphological, as well as extreme climatic characteristics, permafrost etc. The main goal of this research was to conduct an independent scientific expertise of assessment of the environmental conditions during the implementation of one the largest transport projects in Siberian region.

The natural conditions were assessed according to the following indicators: extreme values of air temperature and precipitation, strong winds, snow cover thickness, avalanche danger, seismicity and some slope processes. Analysis was made using various map documents, statistical data, results of expert interviews with the representatives of regional ministries of transport and ministries of economic development, universities and research institutes. For the analysis of extreme climatic characteristics data from weather stations of the study region were used. The entire area of projected road construction was divided into several sections, where it is necessary to take into account certain parameters mainly extreme natural phenomena. As a result the assessment of the potential natural risks during the construction and further operation of the railway was made.

Keywords: natural conditions, railway line construction, mountains, Tuva and Krasnoyarsk Krai

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Assessment of interlinkages among industrialization, climate change, and forest fire activity: Thematic study of the Republic of Sakha (Yakutia), Russia

*Kiunnei Kirillina[1], Wanglin Yan[1]

1. Graduate School of Media and Governance, Keio University SFC

Forest fires play a critical role in shaping the ecosystem and atmospheric patterns. In turn, fire regimes are highly influenced by climate and human activities. Natural cycles, human activities like land-use changes and fire exclusion, and human-caused climate change can also influence the likelihood of fires. This study aimed to identify the causes underlying the increase of fire activity in one of the most fire-hazardous regions of Russia, the Republic of Sakha (Yakutia). The forest in this republic is performing the important function of permafrost protection. Deforestation might cause a catastrophic permafrost degradation, as the decrease of forests there mainly occurs due to fires.

To understand the patterns of historical fire activity, we analyzed the past history of fire events in the Sakha Republic through a newly developed approach for historical fire regimes characterization. Then, to identify the exact cause of intensification of fire activity was constructed an analytical approach for the assessment of interlinkages among industrialization, climate change, and forest fire activity. The study found that the main contributor to the increased historical fire activity in the republic was climate warming documented there since the 1960s, especially in spring season, which affected the overall duration of the fire season. As one main cause of recent expansion of fires, this research identified as significant the socioeconomic and land use changes undergone on the territory of the republic since the 2000s, which have resulted in extensive use of forest and forested land, and increased number of anthropogenic fires and related atmospheric changes.

Keywords: forest fires and climate change, land use changes, anthropogenic fires, GHG emissions

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Quantitative Evaluation of Winter Daily Precipitation over Northern Japan

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Snowfall is an important parameter for water resources. An accurate, quantitative evaluation is needed to clarify the impact of global warming on snowfall and vice versa. For that evaluation, a gridded precipitation data set based on rain-gauges is suitable, because rain-gauges measure precipitation directly. However, rain-gauge data include systematic biases due to interpolation and observation biases. For example, the long-term average, daily gridded precipitation data from APHRO_JP (P) underestimates by 30% the sum of evapotranspiration (E) and inflow (R) from dam catchments located in Northern Japan. We know this because if APHRO_JP was accurate, P should be equal to $R+E$ and it is not. It was reported that the annual mean precipitation of Japan was well simulated in the non-hydrostatic regional climate model (NHRCM, spatial resolutions 5 km/2 km) produced by the Meteorological Research Institute (MRI). From the above, we validated the interpolation bias of APHRO_JP using precipitation from the NHRCM to quantitatively evaluate winter precipitation over Northern Japan. The bias in the water balance from the dam catchments was reduced to 1% after adjusting for three systematic biases.

First, we validated and adjusted the interpolation bias. We created daily precipitation gridded data based on the distribution of the Automated Meteorological Data Acquisition System (AMeDAS) using hourly precipitation from the NHRCM (spatial distribution 2 km) and we compared it with precipitation from the NHRCM. We found that precipitation from the Mesh precipitation climatology which is used in APHRO_JP underestimated precipitation over mountain areas where rain-gauges were not set up. Because of this, APHRO_JP underestimated winter precipitation over mountain areas by approximately 3 mm/day. This daily precipitation bias over mountain areas was halved when we used climatology based on precipitation from the NHRCM instead of Mesh precipitation climatology.

Even with this adjustment, precipitation over mountain areas was still underestimated. This stemmed from the interpolation method used to predict rainfall, because the climatology indicate that the ratio of precipitation increases seasonally with elevation over mountain areas. This underestimation was controlled by an adjustment to the interpolation bias from the precipitation pattern detected by an Empirical Orthogonal Function (EOF) analysis.

On the basis of these validation results, we created daily precipitation gridded data based on the AMeDAS rain-gauge. We then applied the three adjustments from the climatology, precipitation pattern and precipitation undercatch and evaluated their contribution. We found that the annual precipitation over Japan was 2054 mm/year, which was an 18% increase on APHRO_JP. Furthermore, at the four dam catchments in Northern Japan, this adjusted precipitation explained 99% of the precipitation estimated by inflow from the dam catchments and evapotranspiration.

Finally, we measured the contribution of the systematic bias in winter precipitation in Northern Japan (138.5–141˚E, 36.8–38.8˚N). Precipitation was increased 11% by changing the climatology and increased 12% by adjusting for precipitation undercatch. The impact of the precipitation pattern adjustment was small. For extreme events, the adjustment effect was different. On average, in the four dam catchments,

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precipitation was increased 18% by the change of climatology 7% by adjustment for precipitation undercatch. However, these ratios were different at each dam, and in dams where the catchments were in high mountain regions, there was a much greater effect from a change in the climatology. Because there are few rain-gauges in high mountain regions, it important to change climatology used in APHRO_JP. Furthermore, our results indicate uncertainty in precipitation from internal variability when the precipitation pattern adjustment was not used. Our application of these adjustments to APHRO_JP reduced systematic bias and improved precipitation measurements.

Keywords: APHRO_JP, winter precipitation, water resource

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Seasonal variation of wetland carbon dioxide and methane fluxes measured by automatic chambers at the Bakchar bog, West Siberia

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1. National Institute for Environmental Studies, 2. V.E. Zuev Institute of Atmospheric Optics, 3. M.V. Lomonosov Moscow State University

Wetland CO_2 and CH_4 fluxes were observed at the Bakchar bog (N56˚, E82˚), West Siberia. Measurements were performed by two solar powered automated systems, each consisting of NDIR Li-820 CO_2 analyzer, an SnO_2-based methane sensor, six static chambers installed along transects, the air drying and distribution unit, and a datalogger. Observations were made during the May to October period in 2014 to 2017 at two types of open wetlands: mesotrophic open bog and patterned wetland with forested ridges, flat hollows and water pool. Each chamber is automatically opened and closed with pneumatic actuator. Water level is measured in the wetland and surrounding forest locations. Net uptake of CO_2 is observed from the beginning of June through the end of August with a maximum from mid-June through the end of July. Seasonal pattern of methane fluxes showed that CH_4 emission increases at the beginning of June, then weakens gradually in autumn. Seasonal variation of the emissions correlates well with the soil temperature at 5-10 cm depth. Carbon dioxide and methane fluxes correlate spatially; higher methane emissions are observed at wet mesotrophic locations with higher photosynthesis/respiration rates. Lower CH_4 emissions were observed on oligotrophic patterned wetland.

Keywords: methane emissions, wetland, Siberia, CO2 fluxes

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Climatic distances between origin and labor locations for migrants in a changing climate in Siberia by the end of the 21st century

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The goals of our work were to evaluate climatic distances between climates from which potential migrants originate and climates of various regions over Siberia for which they migrate; and evaluate Siberian regions from view points of comfort-discomfort for migrants in current and future climates by the end of the century. We have completed this research from the example of the Krasnoyarsk Territory that is located in the center of Siberia and stretches from the south to north at a distance 2,000 km. Statistics on migrations show that migrants arrive to the Krasnoyarsk Territory from the European Russia and far abroad: Northern Korea, China, Vietnam. We studied four large industrial regions of the Territory for labor migrations. We used two climate variables that reflect winter and summer conditions: mean January and July temperatures. In total, 30 cities were ordinated in the axes of the differences in these temperatures between migrants' origins and migration locations. To characterize the future climates by the end of the century we used January and July temperature departure means from the ensemble of twenty general circulation models from the CMIP5. Two scenarios were used to characterize the range of climate change: a mild RCP 2.6 and a sharp RCP 8.5 climate scenarios. In total, 12 portraits of potential labor migrations were outlined in current and future climates. The "null" point in each portrait showed conditions for the natives of a particular region and the distance from the null to a country of origin showed physiological and psychological discrepancy that migrants should overcome to live in new climate.

Keywords: migration, climate change, transfer function, Siberia, January and July temperatures

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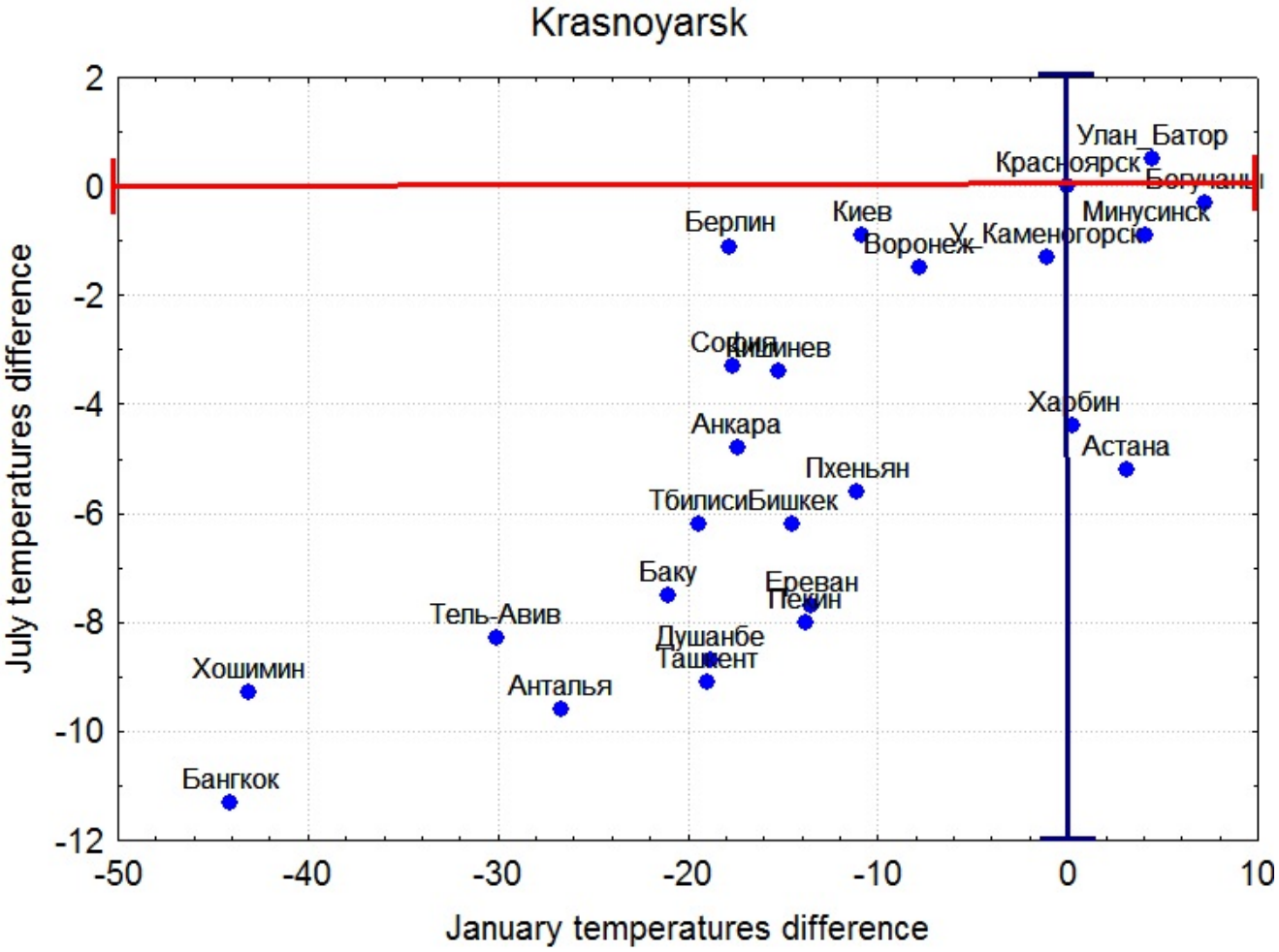

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[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 304 3F

[M-IS01] Environmental, socio-economic and climatic changes in Northern Eurasia

convener:Pavel Groisman(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA), Shamil Maksyutov(National Institute for Environmental Studies), Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS), Dmitry A Streletskiy(George Washington University), Chairperson:Shamil Maksyutov(National Institute for Environmental Studies, Japan), Pavel Groisman(NC State University, USA), Yoshihiro Iijima(Mie University, Japan)

We invite presentations on the biogeochemical cycles, the surface energy budget and water cycle, and climate and ecosystem interactions in Northern Eurasia (land-cover and land-use change, atmospheric aerosols, soil, and permafrost changes that affect and are being affected by climate and ecosystem change), human dimension, and tools to address the Northern Eurasia studies. In environmental studies, our Session foci are on the carbon cycle of Northern Eurasia and on the permafrost changes in Siberia, Asian Mountains, and the Arctic coastal regions.
In the regional water cycle studies, our Session foci are on the changing distribution of precipitation intensity, frequency, especially, in the cold/shoulder season transition periods when surface air temperature is close to 0 deg.C, and on the pattern and seasonal cycle changes of runoff.
In the human dimension studies, our Session foci are on assessments of impact of the ongoing environmental changes in Northern Eurasia on the human well-being and on mitigation strategies development in response to harmful consequences of these changes
The particular foci of this Session will be the studies of changes that impacts regional sustainable development in the Dry Latitudinal Belt of Northern Eurasia that expands through the continent from Pannonian Steppes in the west to the drylands of northern China in the east.
We invite also early career scientists associated with (or interested in) the Northern Eurasia Earth Science Partnership Initiative and its continuation, Northern Eurasia Future Initiative (http://nefi-neespi.org/NEFI-WhitePaper.pdf).

Conveners:
Pavel Groisman, NC State University, USA (pasha.groisman@noaa.gov)
Shamil Maksyutov, National Institute for Environmental JAPAN (shamil@nies.go.jp)
Evgeny Gordov, Siberian Center for Environmental Research and Training, RUSSIA (gordov@scert.ru)
Yizhao Chen, Nanjing Forestry University, CHINA (chenyzvest@gmail.com)

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MIS01-01] Progress and Opportunities in Measurement and Modeling of Arctic Carbon Cycling under a Changing Climate

★Invited Papers

*Qianlai Zhuang[1], Narasinha Shurpali[2], Torsten Sachs[3] (1.Purdue University, 2.University of Eastern Finland, 3.Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MIS01-02] Potential climate change effects on biosystems in Siberia by the 2100s predicted from CMIP5

*Nadezhda Tchebakova[1], Elena Parfenova[1], Amber J Soja[2] (1.Sukachev Institute of Forests, Federal Research Center KSC, Siberian Branch, Russian Academy of Sciences, 2.National Institute of Aerospace, NASA Langley Research Center,)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MIS01-03] Climate Change and Permafrost Degradation in Northern Eurasia: Geographic Impact Assesment

*Dmitry A Streletskiy[1] (1.George Washington University)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MIS01-04] Effects of deforestation of boreal forests on atmospheric fluxes and weather conditions at the local and regional scales

*Alexander Olchev[1,2], Vadim Mamkin[2], Inna Rozinkina[3], Yulia Mukhartova[4], Mikhail Nikitin[3], Ekaterina Tatarinovich[3], Julia Kurbatova[2] (1.Lomonosov Moscow State University, Faculty of Geography , 2.A.N. Severtsov Institute of Ecology and Evolution, Russian Academy of Sciences, 3.Hydrometeorological Research Center of Russian Federation, 4.Lomonosov Moscow State University, Faculty of Physics)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MIS01-05] **Changes in mountain glacier systems and the distribution of main climatic parameters on the territory of Russia (XX -XXI century)**

*Tatiana Khromova[1], Gennady Nosenko[1], Valeria Popova[1], Anton Muraviev[1], Stanislav Nikitin[1] (1.Institute of Geography Russian Academy of Sciences)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MIS01-06] Projection of changes in water balance components across irrigated lands of Central Asia using a high-resolution modeling system

*Anastasiia Pikaleva[1], Ekaterina Nadyozhina[1], Alexandra Sternzat[1], Boris Egorov[1], Sergey Efimov[1], Igor Shkolnik[1] (1.Voeikov Main Geophysical Observatory)

Progress and Opportunities in Measurement and Modeling of Arctic Carbon Cycling under a Changing Climate

*Qianlai Zhuang[1], Narasinha Shurpali[2], Torsten Sachs[3]

1. Purdue University, 2. University of Eastern Finland, 3. Helmholtz Centre Potsdam GFZ German Research Centre for Geosciences

Tremendous progress has been made in the observation and quantification of Arctic carbon cycling with various approaches. A session organized during the 2019 European Geoscience Union meeting showcased this progress with highlights from 17 studies representing different regions of the Arctic. A number of studies investigated the effects of soil freezing on carbon dioxide and methane production, consumption and emissions and the carbon budget in Arctic ecosystems using chamber and eddy flux tower observation techniques. Some of those studies focused on the role of moss, snow and permafrost thawing in carbon fluxes. There were studies that reviewed the methodology of measuring carbon fluxes from Arctic lakes, while several studies examined methane evasions from sea shelves and oceanic environments. Satellite and isotopic data as well as atmospheric transport and inversion modeling have been used in various studies. Several studies used earth system and biogeochemistry models to quantify methane fluxes and wetland area dynamics. The challenges of scaling up carbon balances in fragmented Arctic landscapes were presented, including characterizing and modeling landscape dynamics (e.g., peatland expansion). Based on these EGU session contributions and our own research progress, we present here observations and modeling results on Arctic carbon cycling and identify the challenges and opportunities in this field.

Keywords: Arctic, Carbon dioxide and methane , permafrost, wetlands and lakes, oceanic environment, earth system and biogeochemistry modeling

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Potential climate change effects on biosystems in Siberia by the 2100s predicted from CMIP5

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Regional Siberian studies have already registered climate warming over the last half century from 1960 to 2015 in Siberia. The CMIP5 model simulations show that by the end of the century Siberia would be characterized by a milder climate, with less permafrost coverage: temperature would increase by 3.4˚C (RCP 2.6 scenario) to 9.1˚C (RCP 8.5 scenario) in mid-winter and by 1.9˚C (RCP 2.6) to 5.7˚C (RCP 8.5) in mid-summer; and precipitation would increase by 60 mm (RCP 2.6) to 140 mm (RCP 8.5).

Our goal was to evaluate climate warming consequences for biological systems in Siberia by the 2080s. We developed and used large-scale bioclimatic models and statistical models to evaluate climate effects on vegetation shifts, changes in forest structure and productivity, drylands, agricultural benefits of warming, biotic disturbances, such as infestations of the Siberian moth (*Dendrolimus suprans sibiricus* Tschetv) and a related pathogen needle cast (*Lophodermium pinastri* Chev) in Siberia for the baseline period 1961-1990 and for the 2080s using the RCP 2.6 and RCP 8.5 scenarios of 20 general circulation models from CMIP5.

Principal results are:

Siberian forests are predicted to decrease and shift northwards and forest-steppe and steppe ecosystems are predicted to dominate 50% of Siberia due to the 2080 RCP 8.5 drier climate. Dark taiga would follow the permafrost retreat. Dahurian larch taiga would continue to dominate over continuous permafrost. New temperate broadleaf forest and forest-steppe habitats are predicted in the south;

Agriculture in Siberia would likely benefit from climate warming although potential croplands would be limited by the availability of suitable soils. Traditional crop production may increase by twofold and new crops (maize for grain, gourds) may be introduced in the south, depending on additional irrigation in a drier 2080 climate;

Biotic disturbances. Under the extremely warm RCP 8.5 scenario Siberian moth habitats would considerably shrink and be limited by the main food resources (*Larix spp., Abies sibirica, and Pinus sibirica*) and by future mild winters with frequent thaws that would damage the Siberian moth larvae. Needle-cast of *Pinus sylvestris* was found to be strongly related to precipitation including snow depth rather than summer temperature. In the predicted drier climate, it would shift northwards followed sufficient water and the tree-host *Pinus sylvistris* distribution;

Ecological Landscape Potential for human settlements would improve for 1 (RCP 2.6) to 2 (RCP 8.5) categories over most of Asian Russia, which could lead to a 5- to 7-fold increase in the capacity of the territory to sustain and become attractive to human populations and lead to increased migrations.

Keywords: climate change, CMIP5 , climate warming consequences , biological systems , Siberia

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Climate Change and Permafrost Degradation in Northern Eurasia: Geographic Impact Assesment

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1. George Washington University

The Arctic regions of Norther Eurasia are progressively warming. One of the major concerned of observed and projected warming is presence of permafrost. Limited permafrost observations show that following climatic trends permafrost is warming across the region. The active layer, the layer just above permafrost that is subject to seasonal thawing and freezing, is also increasing. These changes are important for many natural ecosystem processes and also critical in design of the infrastructure on permafrost. This work is utilizing latest available climate input and permafrost-geotechnical modeling in order to locate the areas where permafrost degradation and associated hazards may negatively impact critical infrastructure. The cost of various types of infrastructure is then used to estimate the monetary value of impacted infrastructure and to evaluate the ability of regions to absorb the cost required to maintain infrastructure on permafrost. The results can be used to inform decision makers and planers in areas occupied by permafrost.

Keywords: permafrost, climate change, economics , Arctic

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Effects of deforestation of boreal forests on atmospheric fluxes and weather conditions at the local and regional scales

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Effects of clear-cutting and forest disturbances on weather conditions and atmospheric fluxes at the local and regional scales were investigated by an aggregated approach that includes continuous field measurements of energy and CO_2 fluxes at the recently clear-cut area and in an undisturbed forest stand, as well as modeling experiments using process-based regional and local scale models. Field measurements of energy and CO_2 fluxes were provided at clear-cut area using the eddy covariance method over the three year period following harvest. Results showed a clear dependence of clear-cut net radiation and energy fluxes on surface albedo and amount of grassy and woody vegetation actively regenerated within the clear-cut area after the harvest. The energy budget of the clear-cut area is characterized by higher latent heat (LE) comparing with sensible heat (H) fluxes over the entire period of flux measurements. The seasonal pattern of the Bowen ratio (β=H/LE) is characterized by its gradual decrease from spring to summer. Whereas in the spring and in the first half of June the β value varied usually around 1.0, in the middle of summer the β value decreased to 0.3-0.5. The mean β values for period from May to October were 0.5 in 2016, 0.3 - in 2017 and 0.4 - in 2018. Analysis of cumulative Net Ecosystem Exchange (*NEE*) rates for the entire growing season from May to October for 2016, 2017 and 2018 years showed that the clear-cur area for the periods was a source of CO_2 for the atmosphere. Comparisons of the sensible and latent heat fluxes measured at the clear-cut area and in an undisturbed spruce forest stand situated not far away from the clear-cut area showed that the largest differences in sensible heat, H_2O and CO_2 fluxes between both sites were observed during the first year (2016) after timber harvesting, and were mainly influenced by differences in surface albedo (Mamkin et al 2019). Comparisons of the sensible and latent heat fluxes measured at the clear-cut area and in the spruce forest stand showed that in the undisturbed forest the latent heat fluxes are steadily exceeded the corresponding clear-cut fluxes even in periods with sufficient soil moisture conditions promoting active regeneration and growth of grassy and woody vegetation at the cleared area. Comparisons of the NEE components for the clear-cut and undisturbed spruce forest are revealed significant differences in NEE rates for the first year after forest clearing, and gradual decrease of their disparities in the following years. Whereas the clear-cut area during the first three years after timber harvesting is functioned as a CO_2 source for the atmosphere, the CO_2 balance of undisturbed mature spruce forest in the period was close to zero (Mamkin et al., 2016, 2019).

All obtained results are well agreed with flux estimations provided by a local 3D turbulent exchange model and the COSMO-Ru-NWR model for regional weather predictions. In particular the numerical experiments provided using the COSMO-Ru-NWR model for several modeling scenarios imitating total deforestation of a large area situated within European southern taiga zone showed that total forest disturbances can result in changes of radiation and energy budgets of the area and consequently in increasing the annual amplitude of the air temperature (decrease of winter temperatures and their growth in summer) and in reducing the precipitation amount in all seasons of the year (projected annual decrease is about 4%) (Olchev et al., 2018).

The results obtained in the present study can be very useful for better understanding the effects of forest

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disturbances on atmospheric fluxes at land surface - atmosphere interface and estimating their possible influence on regional weather conditions.

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Keywords: deforestation, boreal forest, clear-cut, eddy covariance, COSMO model, net ecosystem exchange of CO2

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Changes in mountain glacier systems and the distribution of main climatic parameters on the territory of Russia (XX -XXI century)

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Mountain glaciers are vital sources of water worldwide to many densely-populated regions including North Eurasia. Most glaciers are now shrinking, resulting in variable water supplies and sustained sea level rise. Rapid glacier change threatens water, energy and food security. Further glacier mass loss is likely in response to recent climate change, driven by global increases in air temperatures and the production of atmospheric pollutants. However, high altitudes and rugged topography generate regional weather systems that complicate the investigation of the relationship between climate and glacier change. Predictive models need to move beyond the state-of-the-art to couple advanced climate models with accurate representations of glacier processes, and more detailed and reliable data describing the state of mountain glaciers are required to constrain these models, both from monitoring individual glaciers and regional remote-sensing observations.

Glaciation exists on the territory of Russia for thousands of years. Glaciers are located now on islands and archipelagoes of Russian Arctic and in mountain regions of continental part of the country and currently cover the area of about 3,480,000 km². Now there are 18 mountain glacier regions on the territory of continental Russia. We present recent data on glaciers state and changes in these regions based on remote sensing and in situ studies and distribution of main climatic parameters that affect the existence of glaciers: summer air temperature and winter precipitation.

Acknowledgements. This presentation includes the results of research project №. 0148-2019-0004 of the Research Plan of the Institute of Geography, RAS and research project supported by the Russian Geographical Society (grant number 05/2017/RGS-RFBR).

Keywords: mountain glaciers , climate change, Russia, glacier changes

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Projection of changes in water balance components across irrigated lands of Central Asia using a high-resolution modeling system

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1. Voeikov Main Geophysical Observatory

The economy of arid regions in Central Asia is largely based on irrigated agriculture, which critically depends on the amount of regional water deficit. The insufficiency of water resources requires an accurate estimation of water balance components from irrigated lands in order to develop the optimal strategy of water consumption across Central Asia in a changing climate. This is particularly important for irrigated areas with typical spatial scales several kilometers, not captured by up-to-date regional climate models and thus requiring an explicit description of subgrid processes using a sophisticated high-resolution atmospheric boundary layer model.

A series of climate simulations using MGO regional climate model (RCM) at 25 km resolution and a 150-level atmospheric boundary layer model (ABLM) have been carried out aimed to improve the estimation of evapotranspiration from irrigated lands. It has been shown that the detailed description of boundary layer structure over the irrigated area pushes the RCM simulated temperature towards observations (assuming that CRU observational analysis to some extent accounts for the effect of irrigation on temperature).

A sensitivity study has been conducted in order to assess the impact of the changes in the Aral sea mirror during the second half of the 20th century –early 21st century on regional heat and moisture balance. This helps to build a methodology for optimizing the land use on the coastal areas of internal water bodies in the arid zones.

A series of ensemble (30 members) regional climate change projections by 2050-2059 relative to 1990-1999 has been conducted using the RCM-ABLM chain under IPCC RCP8.5 scenario. The analysis shows that the deficit of moisture over the irrigated areas increases by the mid-21st century during the growing season. This implies that the conditions for cultivating traditional agricultural crops in the region will deteriorate if the sources of irrigation water remain unchanged.

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[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 304 3F

[M-IS01] Environmental, socio-economic and climatic changes in Northern Eurasia

convener:Pavel Groisman(NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA), Shamil Maksyutov(National Institute for Environmental Studies), Evgeny P Gordov(Institute of Monitoring of Climatic and Ecological Systems SB RAS), Dmitry A Streletskiy(George Washington University), Chairperson:Dmitry Streletskiy(George Washington University), Pavel Groisman(NC State University, USA), Tetsuya Hiyama(Nagoya University, Japan)

We invite presentations on the biogeochemical cycles, the surface energy budget and water cycle, and climate and ecosystem interactions in Northern Eurasia (land-cover and land-use change, atmospheric aerosols, soil, and permafrost changes that affect and are being affected by climate and ecosystem change), human dimension, and tools to address the Northern Eurasia studies. In environmental studies, our Session foci are on the carbon cycle of Northern Eurasia and on the permafrost changes in Siberia, Asian Mountains, and the Arctic coastal regions.
In the regional water cycle studies, our Session foci are on the changing distribution of precipitation intensity, frequency, especially, in the cold/shoulder season transition periods when surface air temperature is close to 0 deg.C, and on the pattern and seasonal cycle changes of runoff.
In the human dimension studies, our Session foci are on assessments of impact of the ongoing environmental changes in Northern Eurasia on the human well-being and on mitigation strategies development in response to harmful consequences of these changes
The particular foci of this Session will be the studies of changes that impacts regional sustainable development in the Dry Latitudinal Belt of Northern Eurasia that expands through the continent from Pannonian Steppes in the west to the drylands of northern China in the east.
We invite also early career scientists associated with (or interested in) the Northern Eurasia Earth Science Partnership Initiative and its continuation, Northern Eurasia Future Initiative (http://nefi-neespi.org/NEFI-WhitePaper.pdf).

Conveners:
Pavel Groisman, NC State University, USA (pasha.groisman@noaa.gov)
Shamil Maksyutov, National Institute for Environmental JAPAN (shamil@nies.go.jp)
Evgeny Gordov, Siberian Center for Environmental Research and Training, RUSSIA (gordov@scert.ru)
Yizhao Chen, Nanjing Forestry University, CHINA (chenyzvest@gmail.com)

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MIS01-07] Rises and Falls of the Socioeconomic-Ecological Systems along the Silk Road

★Invited Papers

*Jiquan Chen[1], Zutao Ouyang[1], Changliang Shao[2], Ranjeet John[1], Geoffrey M Henebry[1], Pavel Groisman[3] (1.Center for Global Changes and Earth Observation, Department of Geography, Environment, and Spatial Sciences, Michigan State University, 2.Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, 3.NC State University Research Scholar, NOAA National Centers for Environment Information)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MIS01-08] Interdisciplinary study of the mountain geosystems in the Altay-Sayan region

*Margarita Syromyatina[1], Yurii Kurochkin[1], Mariia Andreeva[1], Kirill Chistyakov[1] (1.Institute of Earth Sciences, Saint Petersburg State University, Russia)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MIS01-09] Where in High Mountain Pastures does Snow Seasonality Link Most Closely with Subsequent Land Surface Phenology?

*Geoffrey M Henebry[1], Monika A Tomaszewska[2] (1.Michigan State University, 2.South Dakota State University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MIS01-10] Evaluation of orographic precipitation over Central Asia and its simulated change under a warming environment

*Akiyo Yatagai[1], Ayano Senda[1], Minami Masuda[1], Vinay Kumar[2] (1.Graduate School of Science and Technology/Hirosaki University, 2.Texas A&M University)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MIS01-11] The impact factor of surface spectral albedo in an arid area

*Jiaxi Yang[1], Zhenchao Li[2], Xiaoqing Gao[2], Panmao Zhai[3] (1.University of Chinese Academy of Sciences, 2.Key Laboratory of Land Surface Process and Climate Change in Cold and Arid Regions, Cold and Arid Regions Environmental and Engineering Research Institute, CAS, Lanzhou, China, 3.Chinese Academy of Meteorological Sciences)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MIS01-12] **Northern Eurasia Future Initiative (NEFI) Focus on Human-Associated Extreme Events**

*Pavel Groisman[1,2,3], Alexander Shiklomanov[4], Irina Yesserkepova[5], Sergey Gulev[2], Ildan Kaipov[6] (1. NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA, 2. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia , 3. Hydrology Science and Services Corporation, Asheville, North Carolina, USA, 4. University of New Hampshire, Durham, New Hampshire, USA , 5.Joint Stock Company "Zhasyl Damu", Almaty, Kazakhstan, 6. National Center for Space Research and Technologies, Almaty, Kazakhstan)

Rises and Falls of the Socioeconomic-Ecological Systems along the Silk Road

*Jiquan Chen[1], Zutao Ouyang[1], Changliang Shao[2], Ranjeet John[1], Geoffrey M Henebry[1], Pavel Groisman[3]

1. Center for Global Changes and Earth Observation, Department of Geography, Environment, and Spatial Sciences, Michigan State University, 2. Institute of Agricultural Resources and Regional Planning, Chinese Academy of Agricultural Sciences, 3. NC State University Research Scholar, NOAA National Centers for Environment Information

Our focus is recent fluctuations in the Socioeconomic-Ecological Systems (SES) within the Asian Dryland Belt (ADB) –a region that contains the ancient Silk Road that was, for centuries, the primary route for migration and cultural exchange across Eurasia, as well as trade between east Asia and Europe. Our study advances sustainability science by including institutions as the essential foundation of the three-pillared SES to understand changes in 22 political entities in 17 countries during 1992-2016 (hereafter MacroSES). The ADB includes three broadly-defined subregions: Middle East, Central Asia, and East Asia. Land degradation and land use conversion have occurred at an alarming rate across the region, with shrublands and savannas showing a high degree of turnover across the ADB. Meanwhile, the long term changes in annual precipitation and temperature showed uneven spatial distributions with the numerous hotspots of drying or wetting trends that do not always correspond with the land use. We calculated the relative values of LEI (life expectancy index) , GDPp (gross domestic production per capita), and GPPp (gross primary production per capita) to represent “EconSys”, “EcoSys”, and “SocSys”, respectively. A new sustainable index (SI) was calculated for the 17 MacroSES within the ADB. The balance of the three systems (EconSys, EcoSys SocSys) exhibits distinct temporal trends over the study period. Changes in relationships among LEI, GDPp, and GPPp show that MacroSESs in East Asia were very directional and dynamic, but more stable for the Central Asian MacroSESs, and more variable for the Middle East. One of the major findings is changes in the SI over the study period were attributable to armed conflicts (Iraq, Afghanistan, and Syria) or to reorientation toward a market-driven economy (Mongolia and China). Nevertheless, the three systems in 1992 are in disequilibrium and tilted in favor of ecosystem function, but during 2001-2016, the MacroSESs appear to move in a direction of equilibrium.

Keywords: Sustainability, Asian Drylands Belt, Socioeconomic-ecological systems

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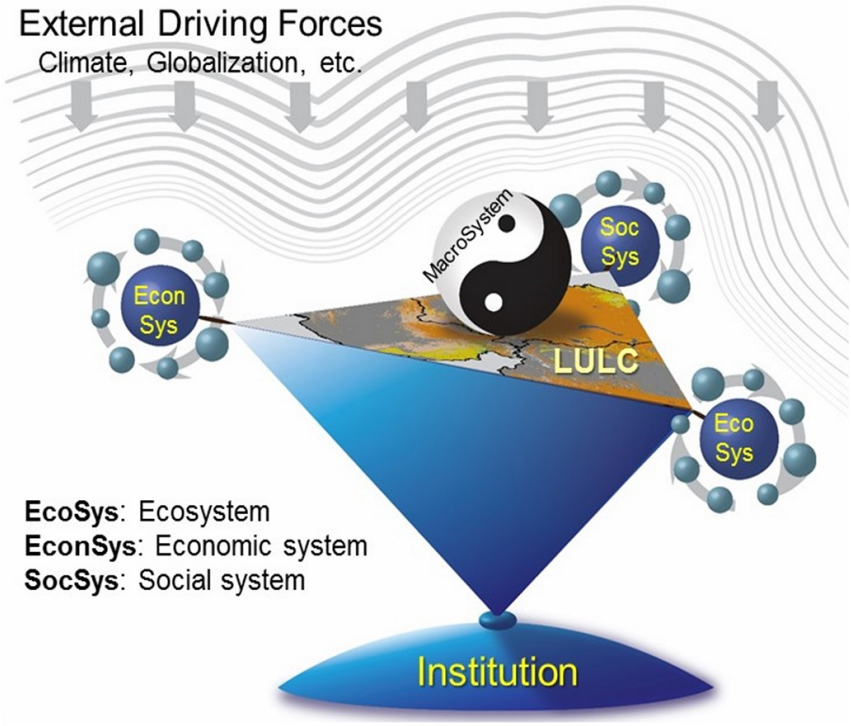

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Interdisciplinary study of the mountain geosystems in the Altay-Sayan region

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1. Institute of Earth Sciences, Saint Petersburg State University, Russia

The results of several projects funded by Russian geographical society and RFBR are presented. The main objective of this regional research is to reveal current state and changes of mountain geosystems mainly under the influence of natural factors as well as socio-economic factors during the last several decades.

Study region is partly located in the Dry Latitudinal Belt of Northern Eurasia and includes several key sites in the Russian, Mongolian and Kazakhstan Altai, in the Tuva Mountains and the Western Sayan Mountains. These mountain systems are the watershed between the Arctic Ocean basin (upper parts of Yenisei and Ob river basins) and Inner Asia closed drainage area (Grate Lake Depression).

Complex geographical field work was conducted during last several years including glaciological, hydrometeorological, hydrochemical, dendrochronological measurements as well as interviewing. Analysis of weather stations' data, remote sensing data acquired from satellites, various map documents and statistical data also was made.

There is positive mean annual air temperature trend in the region during the last several decades (0.2-0.6 degrees Celsius/10ys). But at the same time in recent years the warming trend is weakening in some areas. As for precipitation there is no any statistically significant trend. Such combination of climatic parameters in some areas, for example in the Khovd river basin in Great Lake Depression plays a critical role and we see a tendency to aridization. These facts are well confirmed by dendrochronological streamflow and temperature reconstructions for a longer period.

Dendrochronological analysis results in four regional ring-width chronologies, the longest one is since 1463. Chronologies demonstrate similar year-by-year and long-term variability and contain 10-14 and 29-33-yr cycles. The tree-ring growth is limited mostly by June-July air temperature (R=0.5–0.7). At the same time, chronologies are sensitive to the variability of circulation, hydrological, and glaciological parameters. Strong signal of nature factors permit to use these regional tree-ring chronologies for reconstructions of hydrometeorological parameters.

The water discharge formation in the upper parts of river basins in this region is associated mainly with glaciers. Glacier area and tongue regression was fixed mainly under temperature influence. Large glaciers such as Kozlov and Potanin were retreating at an average rate of 28-34 m/year during last years. At the same time there are some synchronous and non-synchronous changes of glacier retreat rate in different key sites associated basically with location, aspect of a slope, morphological and geomorphological patterns.

Hydrochemical TDS (Total Dissolved Solids) measurements show the dependence on source of nourishment and usually TDS changes from 0-7 ppm in the high-mountain headwaters near glaciers to 65-90 ppm along the river towards the mouth. The water type usually is hydrocarbonate-calcium or hydrocarbonate-magnesian.

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Our research also has an applied aspect. We made an independent scientific expertise consisting in assessment of the natural conditions during the realization of large transport projects in the Siberian region, for example construction of the Elegest-Kyzyl-Kuragino railway line along the mountainous territory. Analysis of such parameters as extreme values of air temperature and precipitation, strong winds, snow cover thickness, avalanche danger and others makes it possible to assess the potential natural risks during the construction and further operation of the transportation systems.

Keywords: mountains, changes, Inner Asia, assesment, interdisciplinary study, physical geography

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Where in High Mountain Pastures does Snow Seasonality Link Most Closely with Subsequent Land Surface Phenology?

*Geoffrey M Henebry[1], Monika A Tomaszewska[2]

1. Michigan State University, 2. South Dakota State University

Within the context of a NASA LCLUC project, we have been working to detect significant changes in metrics of snow seasonality in high mountain pastures across Kyrgyzstan and to associate them, with metrics of land surface phenology in the subsequent growing season, as modulated by terrain features. There are multiple challenges to address including reconciling spatial and temporal scales of observation, topographic normalization of reflectance, seeking ecological signal amidst a welter of variation across multinomial stratifications, and limitations on statistical tests due to autocorrelation, very large sample sizes, and inappropriate neutral model expectations. Working in mountainous landscapes can pose special challenges because terrain features—elevation, slope, aspect, and landform—as well as geographic context can interact to change the ecological expectations of their interactions. We use two types of MODIS products—land surface temperature (MOD11A2, MYD11A2) and snow cover (MOD10A2)—to track the seasonal progression of thermal time and the seasonality of snow cover. We model land surface phenology using NDVI data from Landsat TM/ETM+/OLI sensors as a quadratic function of accumulated growing degree-day calculated from MODIS LST products. Phenological metrics derived from the fitted parameter coefficients include Peak Height (PH) of NDVI and the Thermal Time to Peak (TTP) NDVI. Snow cover seasonality metrics include First Date of Snow (FDoS), Last Date of Snow (LDoS), and Duration of Snow Season (DoSS). We explore how the phenological metrics (PH, TTP) are linked to the seasonality metrics (FDoS, LDoS, DoSS) and how these relationships change as a function of terrain, particularly in contrasting aspects on moderate to steep slopes. The analyses reveal those parts of the landscape where pasture productivity is more vulnerable to changing snow seasonality.

Keywords: Kyrgyzstan, environmental change, land surface phenology, snow seasonality, MODIS, Landsat

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Evaluation of orographic precipitation over Central Asia and its simulated change under a warming environment

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1. Graduate School of Science and Technology/Hirosaki University, 2. Texas A&M University

The Central Asia (CA) region located in the central part of the Eurasian Continent receives little precipitation and thus most parts are classified as arid/semiarid. Here, life and ecosystems largely depend on river discharge from the western Tibetan Plateau. As agricultural water stress has caused shrinkage of the Aral Sea, CA is fragile environment where human–nature interaction plays a key role in hydrological sustainability. It is believed that glaciological water is an important water resource for the CA region; however, if glacier accumulation decreases because of reduced precipitation, water stress could become an increasing problem.

According to the IPCC report based on CMIP5 models, CA precipitation by 2080–2100 is expected to increase by about 10%; however, this prediction is unreliable because numerical simulations are inconsistent. Furthermore, because CA largely depends on mountain water resources, we need to predict future precipitation change for mountain areas. For most models, representation of orographic precipitation is difficult because of resolution limitations. Thus, CMIP results must be downscaled with reference to quantitative observational data. To create an ensemble of multiple models, especially when using “teacher” data, the performance of the multimodel superensemble (MMSE) technique provides excellent results for monsoon Asia.

This study applied the MMSE technique to monthly precipitation data of CA (35˚–60˚N, 50˚–85˚E), focusing on spring (March–May), which is the rainy season in CA. First, we applied the MMSE to CMIP5 “historical” monthly precipitation in spring in accordance with APHRODITE data. Although the APHRODITE dataset can represent the orographic pattern well, it has fewer input data recently; hence, we only used data for 1980–1990 (11 years). We used all 20 registered climate models from the CMIP5 archive. We used 10 years’ data for “training” to decide weighting parameters in accordance with APHRODITE. Then, we “simulated” the final year using the derived parameters. We compared the “simulated” values with APHRODITE data of that year. We repeated this process 11 times such that the data for each year were forecasted by the MMSE.

Comparison of the precipitation pattern of each model to APHRODITE revealed higher correlation coefficients (CCs) for the MMSE result (SUP) (0.6–0.8) than for each model (0.2–0.6) for all years.

The MMSE result for the Middle East (Yatagai et al., 2018) showed the SUP produced the best pattern for each year; however, the long-term trend did not match the observations. Hence, we tried used an SUP with the top six models that showed high CCs between the time series of CA mean precipitation and each model. We selected those models that simulated interannual variation of total precipitation in the CA area as a reflection of how each model simulated the dynamic structure based on the observed forcing. Based on this selection, we applied the MMSE using APHRODITE observational data. The CCs of the top six models in terms of temporal correlation were 0.55, 0.53, 0.48, 0.47, 0.34 and 0.33. Among the other models, some showed strong negative correlation with APHRODITE (CC = −0.65, −0.49 and −0.38); thus, we could exclude them from the MMSE.

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We determined the weighting using two sets: a) the 6 models superior in representing the horizontal variation and b) the 6 models superior in representing the temporal variation for the 11 years. Then, we applied each weighting to the superensemble for RCP8.5 scenario precipitation over CA, especially the high-mountain area. Set a) showed a trend of increasing precipitation in some months in spring; however, set b) showed a robust decreasing trend in all months.

Considering it reasonable to place greater trust in model outputs that are good at representing interannual precipitation variation in CA, we pessimistically predict that spring precipitation in the 2100s will be reduced in the mountain region of CA.

Keywords: Multimodel Superensemble, CMIP, APHRODITE, Glaciological water resources

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The impact factor of surface spectral albedo in an arid area

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Climate is very sensitive to surface albedo. Subtle changes in surface albedo can affect the energy balance of land atmosphere system and cause climate change. Therefore, accurate acquisition of surface albedo parameters and the study of their distribution characteristics are of great significance to regional climate change and to the improvement and validation of land surface process models. As the past studies on the surface albedo are mostly focus on the full-spetrum radiation. And in the third generation of land-surface process models, such as the CLM, LSM, and the later-released CLM4.0 and CLM4.5, the solar radiation is divided into visible and near-infrared radiation, with a wavelength of 0.7 μm as a divide, as well as being divided into direct radiation and scattered radiation in the parameterization process of the surface albedo. However, the absorption and reflection of different wavelengths of sunlight would change by the change of underlying surface. In order to understand the impact factors of surface spectral albedo and provide theory basis for the parameterization of surface albedo, the observational data on the spectral radiation and 2cm soil moisture in Dunhuang, China from July 2017 to December 2018 were analyzed. The reason of choosing Gobi area instead of other areas is it can minimize the impact of cloud cover and other weather conditions on the solar radiation. During the observation period, the surface albedo increased with the wavelength in each season except winter. The surface albedo was affected by the solar altitude and soil moisture, and they exhibited obvious anti-correlations. The annual mean surface albedo of GR, UV, VIS and NIR was 0.25, 0.13, 0.25 and 0.43, while the correlation coefficient with solar altitude was -0.41, -0.08, -0.29 and -0.30, and the correlation coefficient with 2cm soil moisture was -0.60, -0.60, -0.59 and -0.46, respectively. Longer wavelengths correspond to stronger relationship between the surface albedo and solar altitude. In contrast, shorter wavelengths correspond to stronger relationship between the surface albedo and 2cm soil moisture.

Keywords: surface spectral albedo, solar altitude, soil moisture, arid area

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Northern Eurasia Future Initiative (NEFI) Focus on Human-Associated Extreme Events

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1. NC State University Research Scholar at NOAA National Centers for Environmental Information, Asheville, North Carolina, USA, 2. Shirshov Institute of Oceanology, Russian Academy of Sciences, Moscow, Russia , 3. Hydrology Science and Services Corporation, Asheville, North Carolina, USA, 4. University of New Hampshire, Durham, New Hampshire, USA , 5. Joint Stock Company "Zhasyl Damu", Almaty, Kazakhstan, 6. National Center for Space Research and Technologies, Almaty, Kazakhstan

NEFI was conceived at the Workshop "*Ten years of Northern Eurasia Earth Science Partnership Initiative (NEESPI): Synthesis and Future Plans*" in April 2015. One year later, a NEFI White Paper was posted at http://nefi-neespi.org/ and, thereafter, the peer-reviewed NEFI Science Plan paper was published (Groisman et al. 2017). NEFI is a continuation of NEESPI and addresses two significant and intertwined changes with focus on Northern Eurasia: 1) continued and exacerbated change in the global Earth system, and 2) societal changes with need for mitigation and adaptation approaches. The changes have already occurred and keep growing. Their impacts on (and feedbacks to) atmospheric, biospheric, cryospheric, hydrologic, oceanic, and macro-socioeconomic processes are ongoing. To develop effective mitigation and adaptation strategies, future NEFI activities will need to consider three unique features of Northern Eurasia: (1) the sensitivity of land surface characteristics to global change that feedback to influence the global energy budget; (2) potential changes in the Dryland Belt of Northern Eurasia that will have a large influence on the availability of water for food, energy, industry, and transportation; and (3) the role of the evolving social institutions and economies.

While natural processes (except the high amplitude of their variations) are mainly the same as in other parts of the World, human factors and changes in land cover and land use in Northern Eurasia during the past decades were dramatic and unique. They have ultimately transformed human-environment interactions. This in turn has transformed regional land cover and water resources towards conditions that endanger the resilience of natural ecosystems. Institutional changes in Northern Eurasia over the past few decades have led to large changes in the socio-economic fabric of the societies in the region, affecting land use and the natural environment. One overarching challenge has been the transition from command-driven to "transitional" and more market-driven economics in the countries of the region. This phenomenon has occurred at different rates, with differing levels of success, and often with societal costs.

The core motivation of NEFI is to best use science to serve the decision-making process to maintain Earth system health and to sustain society. Therefore, we have to reconsider/expand the definition of term "extreme events" from rare events (as it was used in climatology) to events that are "human-related", i.e., are important for human well-being and are not necessary rare. The Earth climatic system does not know extremes. Unusually rare weather situations can be named disturbances or deviations and these terms do not have emotional connotations. Term "extremes" is used by humans when some events or their anomalous manifestations affect quality of human life, prevent or restrict socioeconomic activities, or endanger human life and/or man-made infrastructure. Using this anthropocentric paradigm, we would rather name "extreme" a gradual thawing of the ground under roads and buildings that causes their destruction than the temperature anomalies above the upper 5% of their daily values. This presentation has a particular focus on several types of human-associated extreme events. They are not necessarily rare,

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but such events can be legitimately named as “human-associated extremes” (HAE) and deserve our attention, when their occurrence cause serious disruption in socioeconomic activity and/or endangers human life and/or when we observed significant changes in their occurrence and intensity. In our presentation, we present a few examples of HAE and their changes over Northern Eurasia.

Reference: Groisman, Shugart, Kicklighter *et al* 2017: Northern Eurasia Future Initiative (NEFI): facing the challenges and pathways of global change in the twenty-first century. *Progress in Earth and Planetary Science,* **4**:41; doi:10.1186/s40645-017-0154-5

Keywords: human-associated extreme events, Northern Eurasia, environmental and socioeconomic changes

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 301B 3F

[M-IS24] Integrated Analysis of Geoscience Observations from the Floor to Surface of the Ocean

convener:Keisuke Ariyoshi(Japan Agency for Marine-Earth Science and Technology), Motoyuki Kido(International Research Institute for Disaster Science, Tohoku University), Daisuke Inazu(Tokyo University of Marine Science and Technology), Narumi Takahashi(National Research Institute for Earth Science and Disaster Resilience), Chairperson:Keisuke Ariyoshi, Motoyuki Kido

Sea bottom pressure data contains various components such as crustal deformation, ocean oscillation, tidal variability, atmospheric change, and instrumental drift. So far, seismologists have treated the ocean oscillation as noise, and ocean physicists have done vice versa (considering crustal deformation as noise). Such problems apply to ongoing undersea acoustic distance measuring and other types of ocean observations. In this session, we welcome contribution on various topics focusing on the complementary relationship between seismology, ocean physics, meteorology, tsunami technology, and other related fields.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MIS24-01] Meteorological Observations at Shionomisaki in cooperation with “Chikyu”, Shinsei-maru and Seisui-maru

*Akira Kuwano-Yoshida[1], Keisuke Ariyoshi[2], Kosei Komatsu[3], Yoshihiro Tachibana[4], Mikiko Fujita[2], Masato I. Nodzu[5], Hatsumi Nishikawa[10], Yoshimi Kawai[2], Naoki Kishita[6], Lyndon Mark Olaguera[5], MIHARU KUBO[8], Kentaro Hase[7], Yuya Matsuyama[6], Minami Masuda[9], Kenta Irie[11], Tetsuji Yoshida[10], Yusuke Watanabe[7], Kosuke Matsuda[12], Syunsuke Aoki[7], Shingo Watanabe[2], Akira Kurisu[13], Shota Yamasaki[7], Hidetaka Hirata[14], Shizuka Akiyama[7], Yoshinori Shigeta[15], Akira Miyata[15], Kai Matsubara[15], Yoshitaka Tada[15], Yasushi Watarai[16], Yusuke Nakamura[16] (1.Disaster Prevention Research Institute, Kyoto University, 2.Japan Agency for Marine-Earth Science and Technology, 3.Graduate School of Frontier Sciences, The University of Tokyo, 4.Faculty of Bioresources, Mie University,, 5.Tokyo Metropolitan University, 6.Kyushu University, 7.Kyoto University, 8.University of The Ryukyus, 9.Hirosaki University, 10.Hokkaido University, 11.Tokyo Gakugei University, 12.Tokyo University of Marine Science and Technology, 13.Okayama University, 14.Nagoya University, 15.Tottori University of Environmental Studies, 16.Rissho University)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MIS24-02] GNSS-A data analysis to estimate the sound speed profile

*Tadashi Ishikawa[1], Yusuke Yokota[2], Shun-ichi Watanabe[1] (1.Hydrographic and Oceanographic Department, Japan Coast Guard, 2.Institute of Industrial Science, the University of Tokyo)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MIS24-03] Comparison of Ocean Bottom Pressure Observation Timeseries with Result of Real Ocean Estimating Models around the Pacific Rim Earthquake Zone

*Yoichiro Dobashi[1], Daisuke Inazu[2] (1.Tokyo University of Marine Science and Technology, 2.Tokyo University of Marine Science and Technology department of marine resouces and energy)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MIS24-04] Experimental challenges for interpretation of in-situ observation of bottom pressure recorders (BPRs) at the seafloor

★Invited Papers

*Hiroyuki Matsumoto[1], Toshinori Kimura[1], Shuhei Nishida[1], Yuya Machida[1], Eiichiro Araki[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MIS24-05] Continuous bottom pressure observation by real-time buoy system for tsunami and crustal displacement

*Narumi Takahashi[1], Kentaro Imai[2], Motoyuki Kido[3], Yusaku Ohta[3], Tatsuya Fukuda[2], Yasuhisa Ishihara[2], Hiroshi OCHI[2], Kensuke Suzuki[2], Ryota Hino[3] (1.National Research Institute for Earth Science and Disaster Resilience, 2.Japan Agency for Marine-Earth Science and Technology, 3.Tohoku Univerisity)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MIS24-06] Looking into the ocean and Earth's interior from their boundary

★Invited Papers

*Yoshio Fukao[1] (1.CEAT / Japan Agency for Marine-Earth Science & Technology)

Meteorological Observations at Shionomisaki in cooperation with “Chikyu”, Shinsei-maru and Seisui-maru

*Akira Kuwano-Yoshida[1], Keisuke Ariyoshi[2], Kosei Komatsu[3], Yoshihiro Tachibana[4], Mikiko Fujita[2], Masato I. Nodzu[5], Hatsumi Nishikawa[10], Yoshimi Kawai[2], Naoki Kishita[6], Lyndon Mark Olaguera[5], MIHARU KUBO[8], Kentaro Hase[7], Yuya Matsuyama[6], Minami Masuda[9], Kenta Irie[11], Tetsuji Yoshida[10], Yusuke Watanabe[7], Kosuke Matsuda[12], Syunsuke Aoki[7], Shingo Watanabe[2], Akira Kurisu[13], Shota Yamasaki[7], Hidetaka Hirata[14], Shizuka Akiyama[7], Yoshinori Shigeta[15], Akira Miyata[15], Kai Matsubara[15], Yoshitaka Tada[15], Yasushi Watarai[16], Yusuke Nakamura[16]

1. Disaster Prevention Research Institute, Kyoto University, 2. Japan Agency for Marine-Earth Science and Technology, 3. Graduate School of Frontier Sciences, The University of Tokyo, 4. Faculty of Bioresources, Mie University,, 5. Tokyo Metropolitan University, 6. Kyushu University, 7. Kyoto University, 8. University of The Ryukyus, 9. Hirosaki University, 10. Hokkaido University, 11. Tokyo Gakugei University, 12. Tokyo University of Marine Science and Technology, 13. Okayama University, 14. Nagoya University, 15. Tottori University of Environmental Studies, 16. Rissho University

Off Kii Peninsula, DONET is distributed to monitor earthquake and tsunami at seafloor in real time. Because observed pressure change at seafloor includes atmospheric and oceanic oscillation as well as crustal deformation, it is important to observe atmosphere and ocean over DONET. On the other hand, Kuroshio affects atmosphere due to heat and moisture fluxes. To observe atmosphere and ocean processes around Kuroshio, meteorological observations at Shionomisaki Wind Effect Laboratory have been conducted in parallel with “Chikyu”, Shinsei-maru, Seisui-maru during 11-20 October (Obs1), 5-9 November (Obs2) and 12-16 November (Obs 3) in 2018. Through the observation period, upper-air observation using GPS sonde has been conducted twice a day at 03 JST and 15 JST. In addition, atmospheric boundary layer has been observed using a drone, a doppler lidar and pilot barons.

Acknowledgement
This study was supported by Kinki Kensetsu Kyokai Research Grant, Kyoto University DPRI Collaborative Research, JSPS KAKENHI Grant Number 17K19093.

Keywords: Kuroshio, DONET, air-sea interaction

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GNSS-A data analysis to estimate the sound speed profile

*Tadashi Ishikawa[1], Yusuke Yokota[2], Shun-ichi Watanabe[1]

1. Hydrographic and Oceanographic Department, Japan Coast Guard, 2. Institute of Industrial Science, the University of Tokyo

Seafloor geodetic observation based on GNSS - Acoustic ranging combination (GNSS-A) is a technique for estimating the absolute position consistent with International Terrestrial Reference Frame. For that reason, it may be called “seafloor GNSS”.

In this observation technique, the distance between the sea-surface ship and seafloor acoustic transponder is measured by acoustic wave. Therefore, the accuracy of sound speed affects the accuracy of position of transponder. For positioning at the centimeter level, it is necessary to have a sound speed with an accuracy of 0.1 m/s. It is not difficult for the current observation instruments to measure within this accuracy. However, it is needed the values at the place and time through which acoustic ray path passed. Because of the complex spatial and temporal variations of the sound speed, it is impossible in practice to make enough observations to cover all these variations in detail. Thus, for centimeter-level positioning, it is not sufficient to use an observed sound speed data only. On the other hand, the observed travel-time data include not only information about the range but also about the sound speed along the ray path. Taking advantage of this fact, we estimate a sound speed correction function. This idea is similar to estimating the atmospheric delay in a precise GNSS data analysis.

To improve an accuracy of positioning, it is important to improve the method to extract the information of sound speed. In this observation, the vessel is moving for about 6 to 20 hours in a region of about 2 to 5 km square. Temporal and spatial variations of sound speed are estimated from the fluctuation of spatial-temporally distributed acoustic data. In this analysis, the geometrical distribution of acoustic data greatly affects the accuracy of sound speed estimation. Therefore, it is necessary to set track line of the ship properly to accurate observation. We investigate the effect of track line on estimation of sound speed. This evaluation is expected to lead to the design of an appropriate observation system.

Keywords: GNSS-A seafloor geodesy, Sound speed profile

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Comparison of Ocean Bottom Pressure Observation Timeseries with Result of Real Ocean Estimating Models around the Pacific Rim Earthquake Zone

*Yoichiro Dobashi[1], Daisuke Inazu[2]

1. Tokyo University of Marine Science and Technology, 2. Tokyo University of Marine Science and Technology department of marine resouces and energy

Ocean Bottom Pressure gauge observation (OBP) has an ability to detect centimeter scale seafloor vertical deformations near the plate boundaries. However, timeseries of OBP contain not only crustal deformation signal but also ocean tide or other oceanic variations, so detection of vertical displacements from OBP variation is not easy task. Especially, non-tidal oceanic variations have common timescale (several days to weeks) with seafloor deformations related to slow earthquakes which have different features from usual earthquake we know. Therefore, removing non-tidal oceanic variations is demanded and one possibility to solve this question is estimating the non-tidal oceanic variations by real ocean estimation model simulations. Actually, this method has already applied to some observation areas.

In this research, we used two realistic ocean estimation models and evaluated how these can reduce the amplitude of non-tidal oceanic variations by applying to multiple ocean area around the Pacific Rim Earthquake Zone.
We introduced a data assimilated product, ECCO (Estimating the Circulation of the Ocean assimilated by JPL) in addition to the single layer-barotropic ocean model (Inazu et al, 2012) and compared these two calculation result with observed OBP time series. In this comparison, we collected OBP timeseries mainly from IRIS Data Management Center and Ocean Networks Canada including Hikurangi Subduction Zone, Cascadia Subduction Zone and Chile Trench.

As a result, we can see the different characteristics of two models and timeseries variation of each sites and evaluate the variation amplitude because 1hPa change means 1cm change in seawater height and seafloor vertical displacement. In case of Hikurangi subduction zone, ECCO can reduce OBP amplitude about 15-25% and standard deviation of after correction is 1.5-2.5 (hPa), and single layer-barotropic ocean model can reduce OBP amplitude about 30%-40% and standard deviation after correction is 1.1-1.8 (hPa). In case of south area of Cascadia subduction zone, the reducing rate is common to each model about 5-15% which isn't so high as Hikurangi subduction zone however standard deviation after correction is 0.9-2.0 (hPa) which is almost same as after correction of Hikurangi subduction zone but in north area of Cascadia subduction zone, standard deviation after correction is 1.6-2.6 (hPa) though two model can reduce amplitude10-20%.
This implies that using model is effective at Hikurangi site and also Cascadia subduction zone is suitable site to detect centimeter scale seafloor vertical deformation from the viewpoint of simple amplitude variation analysis.

Keywords: Crustal deformation, Ocean Bottom Pressure , Physical ocean modeling

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Experimental challenges for interpretation of in-situ observation of bottom pressure recorders (BPRs) at the seafloor

*Hiroyuki Matsumoto[1], Toshinori Kimura[1], Shuhei Nishida[1], Yuya Machida[1], Eiichiro Araki[1]

1. Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

The Japan Marine-Earth Science and Technology (JAMSTEC) involves various underwater technologies related to long-term seafloor or borehole observatories in the seismogenic zone, by which real-time measurement by BPRs (Bottom Pressure Recorders) can contribute to early tsunami detection, slow-slip seismic event monitoring, or possibly crustal deformation’ s measurement etc. JAMSTEC has used the ocean-bottom borehole temperature and pressure simulator for the recent one decade in order to promote our knowledges taking place in the in-situ BPRs’ observations. In the presentation, we present the recent experiment which characterize the hydro-dynamic pressure at the seafloor during an earthquake. A moderately strong earthquake occurred while the authors were evaluating the long-term stabilities of bottom pressure recorders (BPRs) in conjunction with a broadband seismometer in JAMSTEC. In this experiment, a hydro-static pressure simulating that at the seafloor with a depth of 1000 m was applied by using a pressure standard (i.e., a piston gauge). Consequently, the pressurized BPRs were able to completely record the pressure fluctuations induced by the vibrations of a dead weight on the piston-cylinder during the earthquake. The experiment effectively demonstrated the aspects of the hydro-dynamic pressure data obtained through in situ observations during the same earthquake. We were also able to simultaneously obtain records from unpressurized BPRs; these data suggest that the internal mechanics of the BPRs were unaffected by the earthquake. This experimental evidence that BPRs can record true in situ pressure changes without instrumentally induced contamination may be useful for more thorough interpretations of in situ BPR observations by those communities that utilize BPRs.

Keywords: Bottom pressure recorder (BPR), Pressure standard, Broadband seismometer

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Continuous bottom pressure observation by real-time buoy system for tsunami and crustal displacement

*Narumi Takahashi[1], Kentaro Imai[2], Motoyuki Kido[3], Yusaku Ohta[3], Tatsuya Fukuda[2], Yasuhisa Ishihara[2], Hiroshi OCHI[2], Kensuke Suzuki[2], Ryota Hino[3]

1. National Research Institute for Earth Science and Disaster Resilience, 2. Japan Agency for Marine-Earth Science and Technology, 3. Tohoku Univerisity

We have developed real-time observation buoy system for tsunami and crustal displacements and carried out one-year continuous observation around eastern Nankai Trough area. Already we reported a part of the records, for example, tsunami signals brought by Off Southeastern Mie prefecture at 1st April 2016. In general, seafloor pressure observation includes many types of signals, which are crustal displacement, long-term seismic signals, tsunamis, density variation brought by sea current, ocean tide, atmospheric pressure and so on. Therefore, we attached many sensors on the buoy system. Atmospheric sensors to measure pressure, wind speed, wind direction were attached on the buoy, and their data was collected with a sampling of 10 minutes. Precise point positioning, a navigation system using four antennas, and gyro compass were also set on the buoy, and we collected navigation data including buoy position with 2 Hz sampling. Sea floor pressure data using low pass filtered of 0.023 Hz was collected with a sampling of 15 seconds and they were sent to the buoy via the wire end station using acoustic data transmission (Takahashi et al., 2015). The crustal displacement data was also collected, and the buoy has a transducer to communicate with seafloor transponders (Imano et al., 2017; Kido et al., 2018). Many types of observation were succeeded, and next step of our actions is to distinguish these signals. We applied bandpass filter changing the frequencies to the seafloor pressure data. As the results, we found that various signals with relative low frequency were recorded. Although these amplitudes were approximately 0.5 hPa, there were cases with signals with a low frequency of a few minutes, or that from approximately one hour to two hours and with relative short duration. It is possible that slow slip events with various frequencies distribute around off Enshu-nada. In addition, much disturbance was recorded on the pressure sensor during low atmospheric pressure. Such phenomena were recorded by Dense Oceanfloor Network system for Earthquakes and Tsunamis (DONET; Kaneda et al., 2015; Kawaguchi et al., 2015), it is possible that micro tsunami produced by sea surface fluctuation due to variation of atmospheric pressure. In order to clarify the cause of such phenomena, it is essential to observe from seafloor to sea surface. We have successfully observed various physical data both seafloor and sea level in this observatory system. In this presentation, we will introduce various signals recorded by many types of sensors on the real-time buoy system.

Keywords: Tsunami and crustal displacement, real-time observaion, buoy

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Looking into the ocean and Earth’s interior from their boundary

*Yoshio Fukao[1]

1. CEAT / Japan Agency for Marine-Earth Science & Technology

Introduction

Table 1 summarizes the recent ocean bottom observations in which I have been involved. Although these observations were made solely by seismologists, more than half of the published papers were on the oceanic disturbances, including tsunamis, infragravity (IG) waves, internal tides and frontal bores. Less than half were reports on the solid Earth disturbances including VLF earthquakes and slow seafloor deformation. This fact indicates importance of collaboration of oceanographers and seismologists to analyze and interpret the ocean bottom records. I will pick up several topics from Table 1 to explain what may be required to reach a correct interpretation of the records.

Example studies

No. 2. Dispersive IG waves incoming to the off-Aogashima pressure gauge array (A-array), south of Japan, were backprojected by the method conventionally used in seismology. The results were combined with oceanographic information about the spatiotemporal variation of significant wave heights of IR waves provided by WAVEWATCH III. This combination made it possible to locate the excitation sources of the observed IR waves.

No. 3. Off Miyagi, Japan, 42 tilt events dipping landward in a direction perpendicular to the trench axis were detected by a triaxial accelerometer and a tilt-output from BBOBS through an observational period of 10 months. The possibility of seafloor tilting was precluded by a parallel oceanographic observation using a current-meter operated in a limited period. The current record showed that each tilt event was associated with landward flow of cold water. The thermometer inside the accelerometer confirmed that a tilt event was always associated with temperature drop. Clearly, the recorded tilt events were consequences of the frontal passages of advancing bores (solitary waves characterized by an upsloping surging front followed by cold waters). It would be essential for a single station observation to deploy multiple seismological and oceanographic instruments on the seafloor

No. 6. Using the A-array records, we detected the first-mode M2 internal tidal waves propagating with a horizontal phase speed of ~1 m/s in the onshore and offshore directions over the array along the eastern slope of Aogashima Island. The PSD of the internal tide was ~3000 times smaller than that of the M2 external tide. A tide-resolving ocean circulation model (JCOPE-T) was used to simulate the bottom pressure variations at the array. The analysis of the simulated records well reproduced the observed onshore and offshore internal tidal waves. This work represents a good example of collaborations of seismologists and oceanographers.

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No. 11. Slow deformation of the seafloor with a time scale of hours was detected on the records from the far-off Torishima pressure gauge array (B-array) deployed near the Izu-Bonin Trench. Retrieval of signal of this time scale is in general challenging because of the overlaps of tidal disturbances of larger amplitudes and air-pressure disturbances of possibly comparable amplitudes. I developed a method to remove effects of these oceanic and atmospheric disturbances to detect seafloor displacement including its permanent component.

Discussion

Based on these limited experiences, I suggest several possible collaborative works between oceanographers and seismologists. Suggestion includes (No.2) monitoring of the IG wavefield in the Pacific Ocean using data from the seafloor networks such as DONET, S-net and NEPTUNE, (No.3) quantification of internal bores generated in the deep ocean by long-term oceanographic observations at the sea bottom, (No.6) update of a tide-resolving ocean circulation model such as JCOPE-T by assimilating data from the seafloor networks, and (No.11) use of the tide-resolving ocean circulation model to remove “noises” of oceanic and atmospheric origins to retrieve “signals” from the Earth’s interior.

Keywords: ocean bottom observation, pressure gauge, array observation

Table 1. Recent results from our ocean bottom observations

Phenomenon	No	Observation target	Instrument	Sytem	Authors	Year	Journal	Other tools
Ocean	1	Infragravity waves	OBP	DONET	Tono et al.	2014	EPS	
	2	Infragravity waves	OBP	A-array	Tonegawa et al.	2016	JGR-Oceans	HINDCAST/ GLOBAL_IG
	3	Frontal bores	OBA+OBT	Off-Miyagi	Fukao et al.	2016	JGR-Oceans	Currentmeter+ Thermometers
	4	Tsunamis	OBP	A- array	Fukao et al.	2018	Sci. Adv.	JAGURS code
	5	Tsunamis	OBP	A- array	Sandanbata et al.	2018	PAGEOPH	
	6	Internal tide	OBP	A-array	Fukao et al.	2019	JGR-Oceans under review	JCOPE-T
Ocean/ Solid Earth	7	Island deformation by tsunamis	OBP	A-array	Nishida et al.	2019	JGR	BBS on Aogashima Is.
Solid Earth	8	VLF earthquakes	BBOBS	Off-Kii array	Sugioka et al.	2014	Nature Geo.	
	9	VLF earthquakes	BBOBS	DONET	To et al.	2015	PEPI	
	10	Ambient HF seafloor noise	OBS	Off Shikoku array	Tonegawa et al.	2015	Nature Com.	
	11	Slow seafloor uplift	OBP+ BBOBS	B-array	Fukao et al.	2019	in progress	

OBP: Ocean Bottom Pressure Gauge BBS: BroadBand Seismometer on land (3-components)
OBS: Short-period Ocean Bottom Seismometer (3-components)
BBOBS: BroadBand Ocean Bottom Seismometer (3-components)
OBT: Tilt-outputs from BBOBS (2-components)
A-array: Off Aogashima array of OBPs with BBOBS at one site
B-array: Far-off Torishima array of OBPs with BBOBS at one site

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_25

[M-IS24] Integrated Analysis of Geoscience Observations from the Floor to Surface of the Ocean

convener:Keisuke Ariyoshi(Japan Agency for Marine-Earth Science and Technology), Motoyuki Kido(International Research Institute for Disaster Science, Tohoku University), Daisuke Inazu(Tokyo University of Marine Science and Technology), Narumi Takahashi(National Research Institute for Earth Science and Disaster Resilience)

Sea bottom pressure data contains various components such as crustal deformation, ocean oscillation, tidal variability, atmospheric change, and instrumental drift. So far, seismologists have treated the ocean oscillation as noise, and ocean physicists have done vice versa (considering crustal deformation as noise). Such problems apply to ongoing undersea acoustic distance measuring and other types of ocean observations. In this session, we welcome contribution on various topics focusing on the complementary relationship between seismology, ocean physics, meteorology, tsunami technology, and other related fields.

[MIS24-P01] A simultaneous observation from seafloor to atmosphere by using “Chikyu” and DONET

*Keisuke Ariyoshi[1], Takeshi Iinuma[1], Shuhei Nishida[1], Yuya Machida[1], Yasumasa Miyazawa[1], Toru Miyama[1], Hiroshi Uchida[1], Akira Nagano[1], Masahide Wakita[1], Mikiko Fujita[1], Tatsu Kuwatani[1], Amane Fujiwara[1], Katsunori Kimoto[1], Yoshiyuki Nakano[1], Yoshimi Kawai[1], Kaoru Ichikawa[2], Takuya Hasegawa[5], Akira Kuwano-Yoshida[3], Akiko Toh[4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Kyusyu University, 3.Kyoto University, 4.The University of Tokyo, 5.Tohoku University)

[MIS24-P02] Spatio-temporal variation of water pressure on the sea bottom in the Kuroshio region south of Kii Peninsula

*Kosei Komatsu[1,2], Akira Kuwano-Yoshida[3], Keisuke Ariyoshi[4] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3.Disaster Prevention Research Institute, Kyoto University, 4.Japan Agency for Marine-Earth Science and Technology)

[MIS24-P03] GPS-A measurement considering the existence of internal gravity wave

*Motoyuki Kido[1], Ryo Matsui[2], Yoshihiro Niwa[3], Chie Honsho[2] (1.International Research Institute for Disaster Science, Tohoku University, 2.School of Science, Tohoku University, 3.Ocean Alliance, the University of Tokyo)

[MIS24-P04] Measurement of precipitable water vapor using small and lightweight microwave radiometer

*Masahiro Minowa[1], Shigeaki Okumura[1], Shuhei Inoue[1], Yuya Takashima[1], Akira Kuwano-Yoshida[2], Satoru Oishi[3], Toshikazu Onishi[4], Hideo Ogawa[4] (1.FURUNO ELECTRIC CO., LTD., 2.Kyoto Univ., 3.Kobe Univ., 4.Osaka Pref. Univ.)

[MIS24-P05] Observation Across the Large-meander Path of the Kuroshio South of Japan by a Saildrone

★Invited Papers

*Akira Nagano[1], Kentaro Ando[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

[MIS24-P06] Variations in ocean bottom pressure associated with the retreat of the Oyashio current off the southeastern coast of Hokkaido, Japan

*Takuya Hasegawa[1], Akira Nagano[2], Hiroyuki Matsumoto[2], Keisuke Ariyoshi[2], Masahide Wakita[2] (1.Tohoku University, 2.JAMSTEC)

[MIS24-P07] Detection of seafloor crustal deformation from ocean bottom pressure data after applying amplitude corrections on non-tidal components in Hikurangi subduction margin

*Tomohiro Inoue[1], Tomoya Muramoto[2], Daisuke Inazu[3], Yoshihiro Ito[4], Ryota Hino[5], Kazuaki Ohta[4], Syuichi Suzuki[5] (1.Kyoto University, 2.National Institute of Advanced Industrial Science and Technology, 3.Tokyo University of Marine Science and Technology, 4.Disaster Prevention Research Institute, 5.Tohoku University)

A simultaneous observation from seafloor to atmosphere by using “Chikyu” and DONET

*Keisuke Ariyoshi[1], Takeshi Iinuma[1], Shuhei Nishida[1], Yuya Machida[1], Yasumasa Miyazawa[1], Toru Miyama[1], Hiroshi Uchida[1], Akira Nagano[1], Masahide Wakita[1], Mikiko Fujita[1], Tatsu Kuwatani[1], Amane Fujiwara[1], Katsunori Kimoto[1], Yoshiyuki Nakano[1], Yoshimi Kawai[1], Kaoru Ichikawa[2], Takuya Hasegawa[5], Akira Kuwano-Yoshida[3], Akiko Toh[4]

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Slow earthquake [1] including very low-frequency earthquake migrates along strike direction at depth about 30 km, which has been detected from inland seismic observation networks [2]. This migration of slow earthquake is thought to occur in the shallower part near the trench [3], which would be important to monitor the generation process of megathrust earthquakes, in order to classify hydraulic pressure change on the sea bottom into crustal deformation and oceanic oscillation. Toward the monitoring, we have conducted simultaneous observations from seafloor to atmosphere by using DONET and Scientific Deep Sea Drilling Vessel “Chikyu”. In our presentation, we will introduce our observations and collaboration with other related observational campaigns.

References [1] S. Ide et al., *Nature* 447, 76-79 (2007). [2] K. Obara & S. Sekine, *Earth Planets Space* 61, 853-862 (2009). [3] S.Y. Schwartz & J.M. Rokosky, *Rev. Geophys.* 45, RC3004 (2007).

Keywords: subduction zone, megathrust earthquake, ocean current

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Spatio-temporal variation of water pressure on the sea bottom in the Kuroshio region south of Kii Peninsula

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1. Graduate School of Frontier Sciences, The University of Tokyo, 2. Atmosphere and Ocean Research Institute, The University of Tokyo, 3. Disaster Prevention Research Institute, Kyoto University, 4. Japan Agency for Marine-Earth Science and Technology

Profiles of water mass and horizontal current-velocity were observed from the sea surface down to the bottom on the 13 points of the Dense Ocean floor Network system for Earthquakes and Tsunamis (DONET) arranged south of Kii Peninsula, in the cruise of the R/V Shinsei-maru conducted in October 10-21, 2018. The cruise also conducted one-day continuous profiling on the two DONET points. The main purposes of this cruise were to elucidate the spatio-temporal variation of water pressure on the sea bottom associated with the mesoscale eddies and sub-mesoscale frontal disturbances in the Kuroshio region, and to validate the accuracy of detecting several oceanic events followed by fluctuation of the Kuroshio current-path by DONET from the ocean floor, as part of the observational campaigns. In the cruise period, the Kuroshio has taken a large meander path for the first time in twelve years. Therefore, the Kuroshio flowed far away from Kii Peninsula and all the DONET points were covered with the slope waters. We will discuss the capability of DONET to detect relatively calm events in the slope waters on the northern side of the Kuroshio front as an exceptionally rare case.

Keywords: Kuroshio, DONET, water pressure, Kuroshio large meander

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GPS-A measurement considering the existence of internal gravity wave

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In the GPS-A analysis, the traditional “Layered Model”, in which sound speed in ocean is assumed to be stratified, was widely adopted by research groups. However, the “Gradient Model”, dealing with large scale horizontal spatial inhomogeneity as a linear slope, is recently in progress. Persistent horizontal inhomogeneity was proved to be solved as a time-invariant gradient using moving survey for the site of 3 or more transponders or point survey for 5 or more transponders. For the latter case, even time-varying gradient can be solved for every ranging shot in theoretical, however, the theory cannot be applicable in actual observed data. We consider that the time-varying inhomogeneity is caused by internal gravity wave (IW) for its periodical fluctuation in apparent positioning.

In this study, we first explored the critical wavelength of IW that violates the gradient approximation using a synthetic test. The critical wavelength is found to be comparable to the horizontal extent of seafloor transponder array, which roughly corresponds to the depth of the site. Next existence of such short wavelength IW around our observation site was examined by realistic numerical simulation. We employed 2-D transection that intersect from the Izu-Bonin ridge (main excitation source of IW) to the Kumano-nada (one of our observation site), where local tidal current is nearly parallel to its transect. IWs excited by the interaction between barotropic tidal current associated with the four major constituents and seafloor topography were computed. Although long wavelength IW (~100 km) due to the M_2 constituent was dominant, non-negligible amount of short wavelength IWs were also observed, which were generated through cascade-down process with non-linear interaction. We conducted synthetic tests of GPS-A positioning with time-varying sound speed field that constructed from the computed IW field with a given reference potential density profile and found that the obtained time series of apparent position has quite similar frequency and amplitude to those observed in real data. We also found that the most significant cause of the systematic error in GPS-A positioning comes from relatively longer period (~3 hours) IW in the deep portion, while IW in the shallow part can be removed by time average due to its short enough time period (~1 hour).
In order to model such feature in the GPS-A analysis beyond the Gradient Model, we proposed “Disturbance Model” that assigns individual anomalous sound speed in the deep portion for each transponder rather than assuming a simple geometry in the perturbation field. In the Disturbance Model, additional surface platform is needed to balance the increase of unknowns describing sound speed field. Autonomous surface platforms are developed recently, which will help multi-surface-platform observation. We are now investigating the optimum configuration of the multi-surface-platform using both analytical and numerical approaches.

Keywords: GPS-Acoustic, sound speed in ocean, internal gravity wave, seafloor crustal deformation

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Measurement of precipitable water vapor using small and lightweight microwave radiometer

*Masahiro Minowa[1], Shigeaki Okumura[1], Shuhei Inoue[1], Yuya Takashima[1], Akira Kuwano-Yoshida[2], Satoru Oishi[3], Toshikazu Onishi[4], Hideo Ogawa[4]

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Microwave radiometer passively measures the radiation from water vapor. We placed a small and lightweight proto-radiometer at Shionomisaki Wind Effect Laboratory, Disaster Prevention Research Institute, Kyoto University (latitude: 33.4466, longitude: 135.7563). We are trying to develop the real-time device which can measure the precipitable water vapor (PWV) without any compensation information. Because the proto-radiometer is small and weight is light, it should be easy to mount it on the moving vehicles like ships. In this study, we show the measurement results from 27th, Sep., 2018 to 14th, Jan., 2019 which includes the atmosphere and ocean and oceanic observations duration with “Chikyu”, “Shinsei-Maru”, “Seisui-maru”, and Shionomisaki Wind Effect Laboratory.

As the reference data, we use the radiosonde data which launched from Shionomisaki Weather Station, Japan Metrological Agency. The measured data is provided by the Integrated Global Radiosonde Archive. Note that, we also use the radiosonde data launched from Shionomisaki Wind Effect Laboratory. The measurement durations of radiosonde from the laboratory are 11-20th, Oct and 5-15th, Nov, 2018. Additionally, we also use GNSS system (RTNet, Hitachi Zosen, Osaka, Japan) as the reference data. The PWV is estimated by the Zenith Tropospheric Delay, pressure and temperature at measurement location. The PWV estimated using proto-radiometer shows the good agreement with the reference data except for rainfall duration. The results indicate that the small and lightweight proto-radiometer can measure the PWV correctly.

Keywords: microwave radiometer, precipitable water vapor

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Observation Across the Large-meander Path of the Kuroshio South of Japan by a Saildrone

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The Kuroshio large-meander (LM) path formed in September 2017 continues to exist at present. Unlike most of other past LM paths, the present LM path is peculiar in that the current path is quite variable (Nagano et al., 2018). This peculiarity is anticipated to be attributable to the horizontal and/or vertical current structures of the Kuroshio. To understand the dynamics of the Kuroshio LM path, an examination based on potential vorticity is required, and it is essential to obtain spatially high-resolution current velocity vector field. A saildrone, a 7-m length, 5-m height unmanned surface vehicle, is remotely controlled for several months at sea via satellite communication, and collected data are transmitted to us in near real time. Monitoring the location of the Kuroshio by the real time HYCOM nowcast system, we can operate a saildrone to observe variable currents such as an unstable type LM path of the Kuroshio. Current velocity vectors from the sea surface to a depth of approximately 100 m were obtained every 1 min by a 300 kHz acoustic Doppler current profiler (ADCP) installed on a saildrone. In addition, temperature and salinity at the sea surface layer and meteorological parameters (wind speed/direction, humidity, air temperature, etc.) measured by sensors equipped on the saildrone. Based on the nowcast of sea surface current, the Kuroshio current path location was identified and five ADCP velocity transects of the Kuroshio current were obtained. Using the data, we will discuss the dynamics of the LM path.

Keywords: Kuroshio, Large-meander path, Saildrone

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Variations in ocean bottom pressure associated with the retreat of the Oyashio current off the southeastern coast of Hokkaido, Japan

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To investigate the impact of Oyashio current variation on bottom pressure (BP) at observation stations PG1 (41.7040N, 144.4375E) and PG2 (42.2365N, 144.8454E), which are located in the onshore region of the Kuril Trench off Kushiro-Tokachi, altimetric sea surface height (SSH) and ocean bottom pressure (OBP) gauge data were evaluated. Two and a half years after El Nino, during 2007–2008 and 2012–2013, the Oyashio retreated toward the northeast due to warm-core rings, which were inferred from SSH elevations at both stations. Due to the barotropic nature of the Oyashio, BP at PG1 near the offshore edge of the continental shelf is enhanced corresponding to the SSH elevations. Meanwhile, at PG2, BP remained relatively unchanged in spite of the high SSH variability because the main pycnocline adjusted rapidly to the SSH elevations. BP changes at PG1 caused by the northeastward retreat of the Oyashio cannot be neglected to detect BP change by crustal deformations.

Acknowledgements: The authors would like to thank Prof. D. Inazu (Tokyo University of Marine Science and Technology) and Dr. Y. Itoh (Kyoto Univerisity) for their insightful comments. This work was partly supported by the Japan Society for the Promotion of Science (JSPS), Grant-in-Aid for Scientific Research (15H04228, 15H02835, 17K05660).

Keywords: ocean bottom pressure, Oyashio current, sea surface height, El Nino

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Detection of seafloor crustal deformation from ocean bottom pressure data after applying amplitude corrections on non-tidal components in Hikurangi subduction margin

*Tomohiro Inoue[1], Tomoya Muramoto[2], Daisuke Inazu[3], Yoshihiro Ito[4], Ryota Hino[5], Kazuaki Ohta[4], Syuichi Suzuki[5]

1. Kyoto University, 2. National Institute of Advanced Industrial Science and Technology, 3. Tokyo University of Marine Science and Technology, 4. Disaster Prevention Research Institute, 5. Tohoku University

Seafloor observation networks with ocean bottom pressure gauges (OBPG) are widely deployed to detect seafloor crustal deformation derived from tectonic events, such as slow slip events (SSE) now observed in many subduction zones worldwide. Data processing to detect SSE from OBPG data has, however, a serious issue, in which the observed pressure data as the height of the water column above OBPGs includes both the tidal and non-tidal components from oceanic mass shifts, as well as the tectonic components. Because the non-tidal component has amplitude and duration comparable to those of tectonic component, it should be removed from the observed data appropriately for detecting SSE. A global barotropic ocean model has been recently utilized to detect vertical displacement during SSEs from observed pressure data (e.g. Muramoto et al., 2019). Driven by assimilated surface wind vectors and air pressure at the sea surface from atmospheric disturbances (Inazu et al., 2012), the model simulates the total pressure field at the bottom of the sea. However, the modeled non-tidal components are not necessarily coincident with those of the observed records especially in amplitudes. We here propose a novel correction method to reduce the effect of non-tidal component on observed OBP records in the Hikurangi subduction margin.

To reduce the non-tidal component on observed data, we minimize differences between observed and modeled non-tidal components on OBPG data using amplitude correction factor. The observed and modeled components show high correlation with no phase difference, whereas their amplitudes are not completely consistent with each other; the amplitude of the modeled component is generally smaller than that of the observed one in the target area. After removing tidal components and instrumental drift with BAYTAP08 (Tamura et al., 2008), we calculate a correction factor that is a scaling factor of observed/modeled amplitudes of non-tidal components by minimizing the total residual between observed and corrected model amplitude. After multiplying the correction factor to the modeled one, we remove it from the observed OBPG data to reduce the non-tidal variations more effectively than previous works. As the results, variances of time series of OBP record after removal of tide and non-tidal components decreased ~ 30% at most. It is expected that detection ability of tectonic movement is improved by taking pressure differences from the record at a reference site, which is also processed by the same procedure.

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_41

[M-IS24] Integrated Analysis of Geoscience Observations from the Floor to Surface of the Ocean

convener:Keisuke Ariyoshi(Japan Agency for Marine-Earth Science and Technology), Motoyuki Kido(International Research Institute for Disaster Science, Tohoku University), Daisuke Inazu(Tokyo University of Marine Science and Technology), Narumi Takahashi(National Research Institute for Earth Science and Disaster Resilience)

Sea bottom pressure data contains various components such as crustal deformation, ocean oscillation, tidal variability, atmospheric change, and instrumental drift. So far, seismologists have treated the ocean oscillation as noise, and ocean physicists have done vice versa (considering crustal deformation as noise). Such problems apply to ongoing undersea acoustic distance measuring and other types of ocean observations. In this session, we welcome contribution on various topics focusing on the complementary relationship between seismology, ocean physics, meteorology, tsunami technology, and other related fields.

[MIS24-P01] A simultaneous observation from seafloor to atmosphere by using “Chikyu” and DONET

*Keisuke Ariyoshi[1], Takeshi Iinuma[1], Shuhei Nishida[1], Yuya Machida[1], Yasumasa Miyazawa[1], Toru Miyama[1], Hiroshi Uchida[1], Akira Nagano[1], Masahide Wakita[1], Mikiko Fujita[1], Tatsu Kuwatani[1], Amane Fujiwara[1], Katsunori Kimoto[1], Yoshiyuki Nakano[1], Yoshimi Kawai[1], Kaoru Ichikawa[2], Takuya Hasegawa[5], Akira Kuwano-Yoshida[3], Akiko Toh[4] (1.Japan Agency for Marine-Earth Science and Technology, 2.Kyusyu University, 3.Kyoto University, 4.The University of Tokyo, 5.Tohoku University)

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*Kosei Komatsu[1,2], Akira Kuwano-Yoshida[3], Keisuke Ariyoshi[4] (1.Graduate School of Frontier Sciences, The University of Tokyo, 2.Atmosphere and Ocean Research Institute, The University of Tokyo, 3.Disaster Prevention Research Institute, Kyoto University, 4.Japan Agency for Marine-Earth Science and Technology)

[MIS24-P03] GPS-A measurement considering the existence of internal gravity wave

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[MIS24-P04] Measurement of precipitable water vapor using small and lightweight microwave radiometer

*Masahiro Minowa[1], Shigeaki Okumura[1], Shuhei Inoue[1], Yuya Takashima[1], Akira Kuwano-Yoshida[2], Satoru Oishi[3], Toshikazu Onishi[4], Hideo Ogawa[4] (1.FURUNO ELECTRIC CO., LTD., 2.Kyoto Univ., 3.Kobe Univ., 4.Osaka Pref. Univ.)

[MIS24-P05] Observation Across the Large-meander Path of the Kuroshio South of Japan by a Saildrone

★Invited Papers

*Akira Nagano[1], Kentaro Ando[1] (1.Japan Agency for Marine-Earth Science and Technology (JAMSTEC))

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[MIS24-P07] Detection of seafloor crustal deformation from ocean bottom pressure data after applying amplitude corrections on non-tidal components in Hikurangi subduction margin

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Keywords: subduction zone, megathrust earthquake, ocean current

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Spatio-temporal variation of water pressure on the sea bottom in the Kuroshio region south of Kii Peninsula

*Kosei Komatsu[1,2], Akira Kuwano-Yoshida[3], Keisuke Ariyoshi[4]

1. Graduate School of Frontier Sciences, The University of Tokyo, 2. Atmosphere and Ocean Research Institute, The University of Tokyo, 3. Disaster Prevention Research Institute, Kyoto University, 4. Japan Agency for Marine-Earth Science and Technology

Profiles of water mass and horizontal current-velocity were observed from the sea surface down to the bottom on the 13 points of the Dense Ocean floor Network system for Earthquakes and Tsunamis (DONET) arranged south of Kii Peninsula, in the cruise of the R/V Shinsei-maru conducted in October 10-21, 2018. The cruise also conducted one-day continuous profiling on the two DONET points. The main purposes of this cruise were to elucidate the spatio-temporal variation of water pressure on the sea bottom associated with the mesoscale eddies and sub-mesoscale frontal disturbances in the Kuroshio region, and to validate the accuracy of detecting several oceanic events followed by fluctuation of the Kuroshio current-path by DONET from the ocean floor, as part of the observational campaigns. In the cruise period, the Kuroshio has taken a large meander path for the first time in twelve years. Therefore, the Kuroshio flowed far away from Kii Peninsula and all the DONET points were covered with the slope waters. We will discuss the capability of DONET to detect relatively calm events in the slope waters on the northern side of the Kuroshio front as an exceptionally rare case.

Keywords: Kuroshio, DONET, water pressure, Kuroshio large meander

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GPS-A measurement considering the existence of internal gravity wave

*Motoyuki Kido[1], Ryo Matsui[2], Yoshihiro Niwa[3], Chie Honsho[2]

1. International Research Institute for Disaster Science, Tohoku University, 2. School of Science, Tohoku University, 3. Ocean Alliance, the University of Tokyo

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In this study, we first explored the critical wavelength of IW that violates the gradient approximation using a synthetic test. The critical wavelength is found to be comparable to the horizontal extent of seafloor transponder array, which roughly corresponds to the depth of the site. Next existence of such short wavelength IW around our observation site was examined by realistic numerical simulation. We employed 2-D transection that intersect from the Izu-Bonin ridge (main excitation source of IW) to the Kumano-nada (one of our observation site), where local tidal current is nearly parallel to its transect. IWs excited by the interaction between barotropic tidal current associated with the four major constituents and seafloor topography were computed. Although long wavelength IW (~100 km) due to the M_2 constituent was dominant, non-negligible amount of short wavelength IWs were also observed, which were generated through cascade-down process with non-linear interaction. We conducted synthetic tests of GPS-A positioning with time-varying sound speed field that constructed from the computed IW field with a given reference potential density profile and found that the obtained time series of apparent position has quite similar frequency and amplitude to those observed in real data. We also found that the most significant cause of the systematic error in GPS-A positioning comes from relatively longer period (~3 hours) IW in the deep portion, while IW in the shallow part can be removed by time average due to its short enough time period (~1 hour).
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Measurement of precipitable water vapor using small and lightweight microwave radiometer

*Masahiro Minowa[1], Shigeaki Okumura[1], Shuhei Inoue[1], Yuya Takashima[1], Akira Kuwano-Yoshida[2], Satoru Oishi[3], Toshikazu Onishi[4], Hideo Ogawa[4]

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Keywords: microwave radiometer, precipitable water vapor

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Observation Across the Large-meander Path of the Kuroshio South of Japan by a Saildrone

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The Kuroshio large-meander (LM) path formed in September 2017 continues to exist at present. Unlike most of other past LM paths, the present LM path is peculiar in that the current path is quite variable (Nagano et al., 2018). This peculiarity is anticipated to be attributable to the horizontal and/or vertical current structures of the Kuroshio. To understand the dynamics of the Kuroshio LM path, an examination based on potential vorticity is required, and it is essential to obtain spatially high-resolution current velocity vector field. A saildrone, a 7-m length, 5-m height unmanned surface vehicle, is remotely controlled for several months at sea via satellite communication, and collected data are transmitted to us in near real time. Monitoring the location of the Kuroshio by the real time HYCOM nowcast system, we can operate a saildrone to observe variable currents such as an unstable type LM path of the Kuroshio. Current velocity vectors from the sea surface to a depth of approximately 100 m were obtained every 1 min by a 300 kHz acoustic Doppler current profiler (ADCP) installed on a saildrone. In addition, temperature and salinity at the sea surface layer and meteorological parameters (wind speed/direction, humidity, air temperature, etc.) measured by sensors equipped on the saildrone. Based on the nowcast of sea surface current, the Kuroshio current path location was identified and five ADCP velocity transects of the Kuroshio current were obtained. Using the data, we will discuss the dynamics of the LM path.

Keywords: Kuroshio, Large-meander path, Saildrone

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Variations in ocean bottom pressure associated with the retreat of the Oyashio current off the southeastern coast of Hokkaido, Japan

*Takuya Hasegawa[1], Akira Nagano[2], Hiroyuki Matsumoto[2], Keisuke Ariyoshi[2], Masahide Wakita[2]

1. Tohoku University, 2. JAMSTEC

To investigate the impact of Oyashio current variation on bottom pressure (BP) at observation stations PG1 (41.7040N, 144.4375E) and PG2 (42.2365N, 144.8454E), which are located in the onshore region of the Kuril Trench off Kushiro-Tokachi, altimetric sea surface height (SSH) and ocean bottom pressure (OBP) gauge data were evaluated. Two and a half years after El Nino, during 2007–2008 and 2012–2013, the Oyashio retreated toward the northeast due to warm-core rings, which were inferred from SSH elevations at both stations. Due to the barotropic nature of the Oyashio, BP at PG1 near the offshore edge of the continental shelf is enhanced corresponding to the SSH elevations. Meanwhile, at PG2, BP remained relatively unchanged in spite of the high SSH variability because the main pycnocline adjusted rapidly to the SSH elevations. BP changes at PG1 caused by the northeastward retreat of the Oyashio cannot be neglected to detect BP change by crustal deformations.

Acknowledgements: The authors would like to thank Prof. D. Inazu (Tokyo University of Marine Science and Technology) and Dr. Y. Itoh (Kyoto Univerisity) for their insightful comments. This work was partly supported by the Japan Society for the Promotion of Science (JSPS), Grant-in-Aid for Scientific Research (15H04228, 15H02835, 17K05660).

Keywords: ocean bottom pressure, Oyashio current, sea surface height, El Nino

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Detection of seafloor crustal deformation from ocean bottom pressure data after applying amplitude corrections on non-tidal components in Hikurangi subduction margin

*Tomohiro Inoue[1], Tomoya Muramoto[2], Daisuke Inazu[3], Yoshihiro Ito[4], Ryota Hino[5], Kazuaki Ohta[4], Syuichi Suzuki[5]

1. Kyoto University, 2. National Institute of Advanced Industrial Science and Technology, 3. Tokyo University of Marine Science and Technology, 4. Disaster Prevention Research Institute, 5. Tohoku University

Seafloor observation networks with ocean bottom pressure gauges (OBPG) are widely deployed to detect seafloor crustal deformation derived from tectonic events, such as slow slip events (SSE) now observed in many subduction zones worldwide. Data processing to detect SSE from OBPG data has, however, a serious issue, in which the observed pressure data as the height of the water column above OBPGs includes both the tidal and non-tidal components from oceanic mass shifts, as well as the tectonic components. Because the non-tidal component has amplitude and duration comparable to those of tectonic component, it should be removed from the observed data appropriately for detecting SSE. A global barotropic ocean model has been recently utilized to detect vertical displacement during SSEs from observed pressure data (e.g. Muramoto et al., 2019). Driven by assimilated surface wind vectors and air pressure at the sea surface from atmospheric disturbances (Inazu et al., 2012), the model simulates the total pressure field at the bottom of the sea. However, the modeled non-tidal components are not necessarily coincident with those of the observed records especially in amplitudes. We here propose a novel correction method to reduce the effect of non-tidal component on observed OBP records in the Hikurangi subduction margin.

To reduce the non-tidal component on observed data, we minimize differences between observed and modeled non-tidal components on OBPG data using amplitude correction factor. The observed and modeled components show high correlation with no phase difference, whereas their amplitudes are not completely consistent with each other; the amplitude of the modeled component is generally smaller than that of the observed one in the target area. After removing tidal components and instrumental drift with BAYTAP08 (Tamura et al., 2008), we calculate a correction factor that is a scaling factor of observed/modeled amplitudes of non-tidal components by minimizing the total residual between observed and corrected model amplitude. After multiplying the correction factor to the modeled one, we remove it from the observed OBPG data to reduce the non-tidal variations more effectively than previous works. As the results, variances of time series of OBP record after removal of tide and non-tidal components decreased ~ 30% at most. It is expected that detection ability of tectonic movement is improved by taking pressure differences from the record at a reference site, which is also processed by the same procedure.

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 301A 3F

[M-IS25] Recent weather disasters: factors and impact on the atmosphere, hydrosphere, and human beings

convener:Kazuaki Nishii(Graduate School of Bioresources, Mie University), Chairperson:Kazuaki Nishii(三重大学)

A record heavy rain event occurred in July 2018 around western Japan, which caused lots of flood and sediment disasters. The toll of dead and missing was more than 200. The heavy rain was followed by a record heat wave. The highest temperature in a day reached 41.1 degrees Celsius in Kumagaya, which is an all-time high in Japan. This year also suffered from typhoons over and over again. In July 2017, there was another heavy rain event in northern Kyushu area, which also caused tremendous damage. The aims of this session are to discuss factors that caused weather disasters in recent years, and to clarify those impact on the atmosphere and hydrosphere as well as on human beings.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MIS25-01] Heavy Rainfall Event in Middle Viet Nam on 8-9 December 2018 and current QPE/QPF at VNMHA

★Invited Papers

*Kazuo Saito[1,2,3], Le Duc[4,3], Du Duc Tien[5], Mai Khanh Hung[5] (1.Japan Meteorological Business Suport Center, 2.Atmosphere and Ocean Research Institute, the University of Tokyo, 3.Meteorological Research Institute, 4.Japan Agency for Marine-Earth Science and Technology, 5.National Center for Hydro-Meteorological Forecasting, Viet Nam Meteorological and Hydrological Administration)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MIS25-02] High-resolution flow-simulation in Typhoon 21, 2018: tremendous loss of water plants in South Lake Biwa

★Invited Papers

*Satoshi Nakada[1], Hiroki Haga[2], Maho Iwaki[1], Keisuke Hatano[3], Koji Mabuchi[1], Noriko Takamura[1] (1.National Institute for Environmental Studies, 2.Lake Biwa Museum, 3.Japan Water Agency)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MIS25-03] Northern mid-latitude warming prolonged for more than 6 months in 2018 well-predicted by the JMA's operational seasonal prediction system

*Chiaki Kobayashi[1], Ichiro Ishikawa[1] (1.Meteorological Research Institute)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MIS25-04] Synoptic-scale Predictability of Heavy Rain over Western Japan in July 2018

*Akira Kuwano-Yoshida[1] (1.Disaster Prevention Research Institute, Kyoto University)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MIS25-05] Anomalous Moisture Transport and Oceanic Evaporation during a Torrential Rainfall Event over Western Japan in Early July 2018

*Shion Sekizawa[1], Takafumi Miyasaka[1,2], Hisashi Nakamura[1], Akihiko Shinpo[3], Kazuto Takemura[3], Shuhei Maeda[3] (1.Research Center for Advanced Science and Technology, University of Tokyo, 2.Meteorological Research Institute, 3.Japan Meteorological Agency)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MIS25-06] Leading modes of atmospheric circulation variability during the heavy rain event in July 2018

*Kazuaki Nishii[1], Bunmei Taguchi[2], Hisashi Nakamura[2] (1.Graduate School of Bioresources, Mie University, 2.Research Center for Advanced Science and Technology, The University of Tokyo)

Heavy Rainfall Event in Middle Viet Nam on 8-9 December 2018 and current QPE/QPF at VNMHA

*Kazuo Saito[1,2,3], Le Duc[4,3], Du Duc Tien[5], Mai Khanh Hung[5]

1. Japan Meteorological Business Suport Center, 2. Atmosphere and Ocean Research Institute, the University of Tokyo, 3. Meteorological Research Institute, 4. Japan Agency for Marine-Earth Science and Technology, 5. National Center for Hydro-Meteorological Forecasting, Viet Nam Meteorological and Hydrological Administration

On 8-9 December 2018, a heavy rainfall event occurred in Middle Viet Nam, and at Da Nang, a record-breaking rainfall 635 mm was observed in 24 hours from 19 LST (12 UTC) 8 December. This heavy rainfall was relating to the strong cold surge from the north and eastern wind, a typical heavy rainfall situation in Viet Nam.
Since June 2018, a bilateral cooperative project between the Japan International Cooperation Agency (JICA) and the Viet Nam Meteorological and Hydrological Administration (VNMHA) for strengthening capacity in weather forecasting and flood early warning system in Viet Nam has been conducted. This project is relating to S-band radars that installed in Hai Phong (Phu Lien) and Vinh by another grant aid project in September 2017, and the Japan Meteorological Business Support Center (JMBSC) is contributing to four scopes of the project on surface meteorological observation, radar maintenance and products, weather forecasting, and regional weather dissemination.
In the presentation, we introduce the ongoing JICA project, and refer to the heavy rainfall event on 8-9 Decemebr 2018, and the quantitative precipitation estimation (QPE) system based on automatic weather station (AWS) and radar networks and satellite data and the quantitative precipitation forecast (QPF) system based on numerical weather prediction (NWP) at VNMHA. Current and future subjects of the project on the two systems will be discussed.

Acknowledgments: The authors thank to JICA project team members including Kenji Akaeda, Michihiko Tonouchi, Masao Mikami, Kiichi-Sasaki, Hiroyuki Ichijo, Chiho Kimpara, and staff of VNMHA including Nguyen Vinh Thu, Nguyen Dang Quang, and Nguyen Thu Hang. Generation of the precipitation analysis map at VNMHA is partly supported by the national research project “Developing an operational heavy rainfall forecast system for Bac Bo area - Vietnam” (code KC.08.06/16-20; project manager Hoang Duc Cuong).

Keywords: heavy rainfall, JICA project, QPE/QPF, numerical weather prediction, Viet Nam

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High-resolution flow-simulation in Typhoon 21, 2018: tremendous loss of water plants in South Lake Biwa

*Satoshi Nakada[1], Hiroki Haga[2], Maho Iwaki[1], Keisuke Hatano[3], Koji Mabuchi[1], Noriko Takamura[1]

1. National Institute for Environmental Studies, 2. Lake Biwa Museum, 3. Japan Water Agency

The typhoon 21 (Jebi) of Category 5 landed in Japanese main island on September 4 in last year (2018) and catastrophically damaged in mainly west Japan. The typhoon generated the extreme fluctuation of the water level observed in the south basin of Lake Biwa and induced the massive loss of aquatic plants, especially submerged macrophytes in the whole basin. The similar water level fluctuation was first observed in 2nd Muroto Typhoon in September 16, 1961. In recent years, the widespread exuberance of the aquatic macrophytes was often emergent in the south basin, which can severely affect water quality and biota in the lake bed. On the positive side of the aquatic macrophytes, they can absorb the nutrients dissolved in the lake to purify water and spawning ground for freshwater fishes such as carp and crucian. The massive loss of aquatic macrophytes can greatly impact the water environment in the south basin. It is anticipated that the climate change can induce the intense typhoons, understanding the massive loss mechanism of water macrophytes is essential to manage the lake water quality in the near future. This study investigates the physical processes of massive loss of aquatic macrophytes in the south basin based on the high-resolution flow simulation in Lake Biwa to reproduce the extreme fluctuation of the water level in the period of the typhoon 21 attack. We employed the prognostic, three-dimensional, unstructured-grid Finite-Volume Community Ocean Model (FVCOM). This model uses an unstructured triangular grid and provides better flexibility to fit the irregular coastal geometry and bathymetry in the Lake Biwa. The finite-volume approach ensures the conservation of mass necessary to reproduce water level fluctuation in the lake under conditions of a strong atmospheric disturbance. Reanalysis meteorological Grid Point Value datasets of the Meso-Scale Model datasets produced by the Japan Meteorological Agency were input into the FVCOM as mean hourly air temperature, precipitation, cloud cover, relative humidity, dew-point temperature, and wind speed. Hourly-mean data of river inflow to the lake and outflow from the Seta weir located in the south basin were input to the simulation. The initial conditions of water temperature used in the lake simulation were produced by the observational data obtained in August 2018. The simulations began from an initial state of rest, starting 28 August 2018 and was conducted for 2 weeks. Water level data to validate the simulated water level were downloaded from the Water Information System operated by the Ministry of Land, Infrastructure, Transport and Tourism of Japan. The simulation reproduced the extreme fluctuation of the water level, indicating that correlation coefficient between simulated and observed data was more than 0.9. When the water level pronouncedly decreased approximately 1 meter in the typhoon approach near the Lake Biwa, the northward current stronger than 1 m/s was formed in the whole south basin. The bottom shear stress and the drag force on the aquatic submerged macrophytes were calculated based on the simulated data. The bottom shear stress was smaller than critical shear stress suggesting little scouring in the basin bed. On the other hand, the drag force was larger in the areas of the higher vegetation height of submerged macrophytes, indicating that the map of the drag force was similar to the horizontal distribution of the macrophytes loss. These results suggested that the stronger horizontal flow induced by the typhoon wind formed the large drag force on the higher submerged macrophytes leading to uprooting and washout over the speed limit. The south wind over the 20 m/s blowing above the lake surface can induced the flow stronger than 1 m/s to uproot the submerged macrophytes.

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Keywords: Lake Biwa, water plants, flow-simulation, Typhoon

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Northern mid-latitude warming prolonged for more than 6 months in 2018 well-predicted by the JMA's operational seasonal prediction system

*Chiaki Kobayashi[1], Ichiro Ishikawa[1]

1. Meteorological Research Institute

In Japan, record-breaking heavy rains were observed in various places, mainly in western Japan in early July 2018 (Tsuguchi et al, 2018). Thereafter, an extremely high temperature continued mainly in eastern and western Japan (JMA, 2018). East Japan's summer average temperature recorded the highest since the statistical records began in 1946 (JMA, 2018). One of the background factors that brought such a hot summer is that the zonally averaged tropospheric temperature anomaly was high in the northern mid-latitudes (JMA, 2018). Here, we conduct re-forecast and sensitivity experiments by the JMA Seasonal Prediction System (JMA/MRI-CPS2; Takaya et al., 2018) and discuss factors of the formation of the prolonged high temperature anomaly in the Northern mid-latitude.
The seasonal mean 200 hPa height shows positive anomaly in almost all areas of the northern mid-latitudes. This indicates tropospheric warming in the northern mid-latitudes. In particular, the positive anomalies were large in the area from Mongolia to northern China, the vicinity of Alaska Bay, the vicinity of the Labrador Peninsula and in the southern part of the Scandinavian Peninsula. The positive anomalies of the northern mid-latitudes were remarkable in the zonally averaged field, and in the time series, the positive anomalies of the northern mid-latitudes had been continuing from around autumn of 2017.
This prolonged northern mid-latitude positive anomalies were well predicted in re-forecast experiments using a coupled model with initial date at October 28, 2017, despite the fact that the initial date is more than six months ago.
From the end of 2017 to the spring of 2018, the sea surface temperature in the Pacific equator shows anomaly pattern of the La Niña type, then ENSO became neutral during the summer of 2018. From spring to summer, the SSTs over the northern side of the equator showed positive anomalies and the SSTs over the southern side of the equator showed negative anomalies. This SST anomaly pattern continued during spring and summer 2018. This pattern was also well predicted by the model.
In order to investigate the influence of this SST anomaly pattern on the atmospheric anomaly field, we conducted an experiment in which the SST of the tropical Pacific region was nudged to climate SST. The northern mid-latitude height in this experiment (referred to as 'sensitivity experiment' hereafter) was lower than that of re-forecast experiment during the period from the end of 2017 to the summer of 2018. The positive anomalies of convective activity on the north side of the equator were well predicted in the re-forecast experiment, but in the sensitivity experiment, the convective activity anomalies in the same region were weak. This suggests that the SST anomalies in the tropical Pacific has played an important role through the anomalies of convective activity to the formation of the prolonged Northern midlatitude positive height anomalies.

Keywords: summer of 2018, northern mid-latitudes tropospheric warming, AO

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Synoptic-scale Predictability of Heavy Rain over Western Japan in July 2018

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1. Disaster Prevention Research Institute, Kyoto University

Heavy rain event occurred between 5 and 8 July 2018 over western Japan. Japan Meteorological Agency (JMA) had published a press release about the event at 1400 JST 5 July before the event began. Using week ensemble prediction data and reanalysis data by JMA, predictability of westerly jet at middle troposphere and moisture flux at lower troposphere, which are main factors of heavy rain by Baiu front, are analyzed. The ensemble prediction initialized after 12 UTC 30 June well predicted meridional position of westerly jet at middle troposphere. However, horizontal moisture flux maximum at lower troposphere was predicted over the East China Sea at that time. The moisture flux flowing to western Japan was firstly predicted at 00 UTC 1 July. An upper trough developing over Eurasia Continent affected the westerly jet prediction. On the other hand, formation position of Typhoon 1807 (Prapiroon) east of Taiwan determined the zonal position of moisture flux. Predictability of rain continuance is affected by an upper ridge propagated from Eurasia Continent which is well predicted after 3 July.

Keywords: Baiu front, Predictability, Ensemble prediction

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Anomalous Moisture Transport and Oceanic Evaporation during a Torrential Rainfall Event over Western Japan in Early July 2018

*Shion Sekizawa[1], Takafumi Miyasaka[1,2], Hisashi Nakamura[1], Akihiko Shinpo[3], Kazuto Takemura[3], Shuhei Maeda[3]

1. Research Center for Advanced Science and Technology, University of Tokyo, 2. Meteorological Research Institute, 3. Japan Meteorological Agency

Western Japan experienced torrential rainfall in early July 2018, which caused severe floods and landslides especially over western Japan. Japan Meteorological Agency (JMA) reported that this extreme event was associated with extreme enhancement of northward moisture flux and its convergence over western Japan. Some recent studies have pointed out an essential role of surrounding oceans for extreme rainfall events through the anomalous heat and moisture supply to the warm, moist monsoonal airflow. This study investigates anomalous oceanic evaporation during the torrential rainfall event over western Japan based on the objective analysis data from the JMA Meso-Scale Model. We have found that the heavy rainfall was associated with enhanced oceanic evaporation extensively around Japan, especially along the Kuroshio and entirely over the Japan Sea. We then conducted a linear decomposition of local surface latent heat flux anomalies based on the bulk formula to determine factors for the enhanced evaporation. Our results show that the enhanced evaporation under the pronounced southerly inflow toward the extreme rainfall region was mainly due to increase in the surface wind speed along the Kuroshio south of Japan, with an additional contribution from warm SST anomalies to the enhanced moisture inflow into central Japan. In order to quantitatively assess contribution of the enhanced evaporation to anomalous moisture transport in the mixed layer, we also performed a backward trajectory analysis for moist air parcels. It reveals that anomalous moisture supply from the ocean to air parcels along trajectories is dominated by enhanced evaporation due to the stronger surface wind speed, which corresponds to about 20 % of the column water vapor anomaly and about 5 % of the total column water vapor.

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Leading modes of atmospheric circulation variability during the heavy rain event in July 2018

*Kazuaki Nishii[1], Bunmei Taguchi[2], Hisashi Nakamura[2]

1. Graduate School of Bioresources, Mie University, 2. Research Center for Advanced Science and Technology, The University of Tokyo

A continuous heavy rain was observed in western Japan in early July 2018. The aim of this study is to investigate the atmospheric circulation from a view point of leading modes of atmospheric circulation variability and its relationship to external forcings. The first mode of the EOF analysis, applying to interannual variability of 300-hPa westerlies around Japan in early July, represents variability of intensity of the westerlies and precipitation associated with the Baiu front. The score of this mode in 2018 suggests that this mode contributed to the weakening of the westerlies and reduction of precipitation at the climatological position of the Baiu precipitation. The second mode represents meridional shifts of westerly jet axis and position of precipitation. The score of the second mode in 2018 suggests that this mode contributed to northward shift of westerlies and Baiu precipitation. A series of ensemble experiments of an atmospheric general circulation model (AGCM) was conducted under five boundary conditions. The emergence of the first (second) mode is often observed in an experiment in which observed sea surface temperatures are prescribed in the extratropics (tropics), while climatological-mean SST is prescribed in the tropics (extratropics). The score of the second mode is, however, not as large as observed in 2018, which may be one of reasons why the AGCM experiment can not reproduce the heavy rain event in July 2018.

Keywords: modes of atmospheric circulation variability, heavy rain

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_26

[M-IS25] Recent weather disasters: factors and impact on the atmosphere, hydrosphere, and human beings

convener:Kazuaki Nishii(Graduate School of Bioresources, Mie University)

A record heavy rain event occurred in July 2018 around western Japan, which caused lots of flood and sediment disasters. The toll of dead and missing was more than 200. The heavy rain was followed by a record heat wave. The highest temperature in a day reached 41.1 degrees Celsius in Kumagaya, which is an all-time high in Japan. This year also suffered from typhoons over and over again. In July 2017, there was another heavy rain event in northern Kyushu area, which also caused tremendous damage. The aims of this session are to discuss factors that caused weather disasters in recent years, and to clarify those impact on the atmosphere and hydrosphere as well as on human beings.

[MIS25-P01] Environmental Factors affecting 2018 Western North Pacific Tropical Cyclone Activity

★Invited Papers

*Satoshi Iizuka[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[MIS25-P02] **Impact of the Japan/East Sea on the heavy rain event of July 2018 in Japan**

*ATSUYOSHI MANDA[1], Satoshi Iizuka[3], Tkafumi Miyasaka[2,4,5], Hisashi Nakamura[2] (1.Mie University, 2.The University of Tokyo, 3.National Research Institute for Earth Science and Disaster Resilience, 4.Japan Meteorological Agency, Meteorological Research Institute, 5.Japan Meteorological Business Support Center)

[MIS25-P03] Simple sensitivity analysis using weekly ensemble forecasts during the heavy rain event in July 2017

*Yoshimi Kawai[1] (1.Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology)

Environmental Factors affecting 2018 Western North Pacific Tropical Cyclone Activity

*Satoshi Iizuka[1]

1. National Research Institute for Earth Science and Disaster Resilience

Tropical cyclone (TC) activity over the western North Pacific in 2018 is documented. Among 29 TCs in 2018, the number of typhoon ranked on violent typhoon intensity with a maximum wind speed more than 105 knot were seven, which is the largest over the past 40 years since 1979. All of the violent typhoons, including Typhoon 1821 and 1824 making landfall on Japan, were generated over the southeastern quadrant of the western North Pacific, as a TC has enough time to intensify after its formation over the warm tropical ocean. The increase in TC formation frequency over the southeastern quadrant seems to be related to the eastward extension of monsoonal westerlies associated with El Niño. Additionally, the comparison among intense landfalling typhoons implies that the track of Typhoon 1821 was favorable for keeping its intensity owing to a passage over the North Pacific subtropical gyre with large ocean thermal energy.

Keywords: 2018 Typhoons, El Nino, Violent Typhoon

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Impact of the Japan/East Sea on the heavy rain event of July 2018 in Japan

*ATSUYOSHI MANDA[1], Satoshi Iizuka[3], Tkafumi Miyasaka[2,4,5], Hisashi Nakamura[2]

1. Mie University, 2. The University of Tokyo, 3. National Research Institute for Earth Science and Disaster Resilience, 4. Japan Meteorological Agency, Meteorological Research Institute, 5. Japan Meteorological Business Support Center

A role of the neighboring waters in the torrential rainfalls in mid-latitudes during a warm season is debatable and under active research. A torrential rainfall that occurred from 28 June to 8 July 2018 caused widespread and devastating floods, landslides, and mudflows and they led to severe damages over wide areas in Japan, especially in its western part. Approximately 9,000 houses were inundated above the floor level and more than 6,000 buildings were destroyed. From the beginning of the July 2018, the Okhotsk high pressure system intensified, bringing the cold air mass southward to the Japan/East Sea (JES). The southward migration of this cold air-mass and high sea surface temperature in JES caused anomalous upward latent heat flux. We examine the impact of this anomalous latent heat flux on the torrential rainfall, through the numerical simulations with a regional atmospheric model. A simulated rainfall has drastically decreased in the western part of Japan when the latent heat flux is artificially reduced in the JES, indicating that the latent heat flux in the JES plays a role in the torrential rainfall event. A reduced latent heat flux intensifies the static stability of the air-mass flowing into the rainfall areas and modifies the structure of meso-scale fronts, leading to the decrease in rainfall in the western part of Japan. The detailed discussion on the role of the latent heat fluxes in the JES in the rainfall event will be given in this presentation.

Keywords: torrential rain, sea surface temperature, Japan/East Sea

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Simple sensitivity analysis using weekly ensemble forecasts during the heavy rain event in July 2017

*Yoshimi Kawai[1]

1. Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology

It has been pointed out that the heavy rain event that struck a wide area of Japan in the beginning of July 2018 was mainly ascribed to the development of the Okhotsk High and the North Pacific High on a synoptic scale, although meso-scale physics was also important, and that a stationary Rossby wave train that is referred to as the Silk Road pattern appeared over the Eurasian Continent and contributed to strengthening the North Pacific High. The author attempted to identify which area was responsible for the forecast around Japan during the event using a simple sensitivity analysis technique.
The method used here was the ensemble singular-vector sensitivity analysis proposed by Enomoto et al. (2015), based on ensemble forecast data. This technique assumes that initial perturbations growing optimally in a verification domain at a given forecast time can be expressed in a linear combination of the ensemble initial perturbations. They can identify a particular set of coefficients that maximizes a “norm” of forecast perturbations within the verification domain, by solving an eigenvalue problem under the constraint that the norm of the initial perturbations equals unity. The norm was here defined in terms of dry total energy.
For 72-hour forecasts around Japan from the end of June to the beginning of July, sensitivity of their initial conditions was large south of Japan, around Mongol and East Siberia. These signals was able to be traced back to areas west of the Ural Mountains four or five days before the forecast time, and the sensitivity around Caspian Sea was especially large. This is consistent with the Silk Road pattern. The sensitivity signal was able to be tracked back to West Europe, but was no longer clear over the Atlantic Ocean.

Keywords: sensitivity analysis, weekly ensemble forecasts, heavy rain event in July 2017

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-IS Intersection

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_42

[M-IS25] Recent weather disasters: factors and impact on the atmosphere, hydrosphere, and human beings

convener:Kazuaki Nishii(Graduate School of Bioresources, Mie University)

A record heavy rain event occurred in July 2018 around western Japan, which caused lots of flood and sediment disasters. The toll of dead and missing was more than 200. The heavy rain was followed by a record heat wave. The highest temperature in a day reached 41.1 degrees Celsius in Kumagaya, which is an all-time high in Japan. This year also suffered from typhoons over and over again. In July 2017, there was another heavy rain event in northern Kyushu area, which also caused tremendous damage. The aims of this session are to discuss factors that caused weather disasters in recent years, and to clarify those impact on the atmosphere and hydrosphere as well as on human beings.

[MIS25-P01] Environmental Factors affecting 2018 Western North Pacific Tropical Cyclone Activity

★Invited Papers

*Satoshi Iizuka[1] (1.National Research Institute for Earth Science and Disaster Resilience)

[MIS25-P02] **Impact of the Japan/East Sea on the heavy rain event of July 2018 in Japan**

*ATSUYOSHI MANDA[1], Satoshi Iizuka[3], Tkafumi Miyasaka[2,4,5], Hisashi Nakamura[2] (1.Mie University, 2.The University of Tokyo, 3.National Research Institute for Earth Science and Disaster Resilience, 4.Japan Meteorological Agency, Meteorological Research Institute, 5.Japan Meteorological Business Support Center)

[MIS25-P03] Simple sensitivity analysis using weekly ensemble forecasts during the heavy rain event in July 2017

*Yoshimi Kawai[1] (1.Research and Development Center for Global Change, Japan Agency for Marine-Earth Science and Technology)

Environmental Factors affecting 2018 Western North Pacific Tropical Cyclone Activity

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Tropical cyclone (TC) activity over the western North Pacific in 2018 is documented. Among 29 TCs in 2018, the number of typhoon ranked on violent typhoon intensity with a maximum wind speed more than 105 knot were seven, which is the largest over the past 40 years since 1979. All of the violent typhoons, including Typhoon 1821 and 1824 making landfall on Japan, were generated over the southeastern quadrant of the western North Pacific, as a TC has enough time to intensify after its formation over the warm tropical ocean. The increase in TC formation frequency over the southeastern quadrant seems to be related to the eastward extension of monsoonal westerlies associated with El Niño. Additionally, the comparison among intense landfalling typhoons implies that the track of Typhoon 1821 was favorable for keeping its intensity owing to a passage over the North Pacific subtropical gyre with large ocean thermal energy.

Keywords: 2018 Typhoons, El Nino, Violent Typhoon

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Impact of the Japan/East Sea on the heavy rain event of July 2018 in Japan

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1. Mie University, 2. The University of Tokyo, 3. National Research Institute for Earth Science and Disaster Resilience, 4. Japan Meteorological Agency, Meteorological Research Institute, 5. Japan Meteorological Business Support Center

A role of the neighboring waters in the torrential rainfalls in mid-latitudes during a warm season is debatable and under active research. A torrential rainfall that occurred from 28 June to 8 July 2018 caused widespread and devastating floods, landslides, and mudflows and they led to severe damages over wide areas in Japan, especially in its western part. Approximately 9,000 houses were inundated above the floor level and more than 6,000 buildings were destroyed. From the beginning of the July 2018, the Okhotsk high pressure system intensified, bringing the cold air mass southward to the Japan/East Sea (JES). The southward migration of this cold air-mass and high sea surface temperature in JES caused anomalous upward latent heat flux. We examine the impact of this anomalous latent heat flux on the torrential rainfall, through the numerical simulations with a regional atmospheric model. A simulated rainfall has drastically decreased in the western part of Japan when the latent heat flux is artificially reduced in the JES, indicating that the latent heat flux in the JES plays a role in the torrential rainfall event. A reduced latent heat flux intensifies the static stability of the air-mass flowing into the rainfall areas and modifies the structure of meso-scale fronts, leading to the decrease in rainfall in the western part of Japan. The detailed discussion on the role of the latent heat fluxes in the JES in the rainfall event will be given in this presentation.

Keywords: torrential rain, sea surface temperature, Japan/East Sea

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Simple sensitivity analysis using weekly ensemble forecasts during the heavy rain event in July 2017

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It has been pointed out that the heavy rain event that struck a wide area of Japan in the beginning of July 2018 was mainly ascribed to the development of the Okhotsk High and the North Pacific High on a synoptic scale, although meso-scale physics was also important, and that a stationary Rossby wave train that is referred to as the Silk Road pattern appeared over the Eurasian Continent and contributed to strengthening the North Pacific High. The author attempted to identify which area was responsible for the forecast around Japan during the event using a simple sensitivity analysis technique.
The method used here was the ensemble singular-vector sensitivity analysis proposed by Enomoto et al. (2015), based on ensemble forecast data. This technique assumes that initial perturbations growing optimally in a verification domain at a given forecast time can be expressed in a linear combination of the ensemble initial perturbations. They can identify a particular set of coefficients that maximizes a “norm” of forecast perturbations within the verification domain, by solving an eigenvalue problem under the constraint that the norm of the initial perturbations equals unity. The norm was here defined in terms of dry total energy.
For 72-hour forecasts around Japan from the end of June to the beginning of July, sensitivity of their initial conditions was large south of Japan, around Mongol and East Siberia. These signals was able to be traced back to areas west of the Ural Mountains four or five days before the forecast time, and the sensitivity around Caspian Sea was especially large. This is consistent with the Silk Road pattern. The sensitivity signal was able to be tracked back to West Europe, but was no longer clear over the Atlantic Ocean.

Keywords: sensitivity analysis, weekly ensemble forecasts, heavy rain event in July 2017

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[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 9:00 AM - 10:30 AM JST | Sun. May 26, 2019 12:00 AM - 1:30 AM UTC | 302 3F

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), Chairperson:Yasuhiro Murayama(NICT)

Open Science is growing up as a new research paradigm to accelerate scientific innovation. Deployed by ICSU-WDS (2008), G8 Open Data Charter (2013), deployment of Research Data Alliance (2013), OECD Global Science Forum's research projects (2016), and G7 Science Ministers' Communique (2017), it commonly refers to the top-down policies to make results of publicly-funded research freely available and accessible. On the other hand, this term also refers to the participatory bottom-up approaches such as citizen science, crowdfunding, and transdisciplinary research (Kitamoto 2016). It is noted that both approaches envision the transformation of research process to more findable, accessible, interoperable, and reusable one (Wilkinson et al. 2016).
After the JpGU-AGU Great Debate "Role of open data and open science in Geoscience" in JpGU Annual Meeting 2018 and a follow-up session in the AGU Fall Meeting 2018, this session reviews the current broad spectrum of Open Science in an international context. The session welcomes a wide range of papers and posters covering (but not limited to) open research data, open source licenses, data papers and journals, data repository, data sharing infrastructures and platforms, citizen science, crowdsourcing, crowdfunding, transdisciplinary research, capacity building, international networking, and deployment in earth and planetary sciences.

9:00 AM - 9:15 AM JST | 12:00 AM - 12:15 AM UTC

[MGI31-01] WDS: International Coordination for Sustainable FAIR Data, for Science and Society

*Yasuhiro Murayama[1] (1.Strategic Program Produce Office, National Institute of Information and Communications Technology)

9:15 AM - 9:30 AM JST | 12:15 AM - 12:30 AM UTC

[MGI31-02] Japan Data Repository Network (JDARN): Community-based activities for improving the trustworthiness of data repositories

*Asanobu Kitamoto[1,2,4], Hiroko Kinutani[3] (1.National Institute of Informatics, 2.ROIS-DS Center for Open Data in the Humanities, 3.EDITORIA, The University of Tokyo, 4.SOKENDAI)

9:30 AM - 9:45 AM JST | 12:30 AM - 12:45 AM UTC

[MGI31-03] Data Sharing and Open Science: Practice, Expectation, Transparency, and Credit

*Shelley Stall[1] (1.American Geophysical Union)

9:45 AM - 10:00 AM JST | 12:45 AM - 1:00 AM UTC

[MGI31-04] Ethical issues in open science

*Yasuhisa Kondo[1] (1.Research Institute for Humanity and Nature)

10:00 AM - 10:15 AM JST | 1:00 AM - 1:15 AM UTC

[MGI31-05] The perspective of Open Science with consideration of the gap between the Integrated Innovation Strategy and the current state of scholarly communication

*Kazuhiro Hayashi[1] (1.National Institute of Science and Technology Policy)

10:15 AM - 10:30 AM JST | 1:15 AM - 1:30 AM UTC

[MGI31-06] Future evolution of open archives for preprints, posters, and presentations as a key component of open science in the Earth and space sciences

*Brooks Hanson[1] (1.American Geophysical Union)

WDS: International Coordination for Sustainable FAIR Data, for Science and Society

*Yasuhiro Murayama[1]

1. Strategic Program Produce Office, National Institute of Information and Communications Technology

The author's personal consideration on the international academic data enterprise World Data System (WDS) is given in the talk, to discuss the value of international coordination work for sustainable FAIR data, based on the community interest and community-based initiative. Digital data is especially of academic and societal concern today.

Keywords: open science, research data sharing , WDS, international coordination

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Japan Data Repository Network (JDARN): Community-based activities for improving the trustworthiness of data repositories

*Asanobu Kitamoto[1,2,4], Hiroko Kinutani[3]

1. National Institute of Informatics, 2. ROIS-DS Center for Open Data in the Humanities, 3. EDITORIA, The University of Tokyo, 4. SOKENDAI

1. JDARN: establishment and brief history

Japan Data Repository Network (JDARN) is about community-based activities for sharing recent trends in the world and for improving trustworthiness of Japanese data repositories. Its origin is in “Project for assigning DOI on research data” hosted by Japan Link Center (JaLC) between October 2014 through September 2015. This project became a unique forum in which the experts of research data gathered across disciplines for the first time in Japan. As a follow-up activity, Research Data Utilization Forum (RDUF) was established in June 2016, and a few special interest groups (SIG) were later proposed. One of them is “networking domain repository stakeholders in Japan” SIG on October 2017. Then, on October 2018, it was upgraded to “Japan Data Repository Network” to represent our intention to expand the community to more disciplines and more stakeholders.

The purpose of JDARN is to share recent trends of the data repository, and in particular, it focuses on the issue of trustworthiness of data repositories. Trustworthiness plays an important role on decision making when data producers choose one of external services to deposit their data. One of the criteria to show the trustworthiness is CoreTrustSeal (CTS). CTS is one of international certifications on data repositories, and as of February 2018, over 140 data repositories have received certification, but in Japan the number of certification is still few. To understand the reason of delayed adoption of CTS in Japan, we held a seminar "Trustworthy Data Repositories - Forum for Sharing Practical Information about CoreTrustSeal Certification -" on December 2017, so that major data repositories in Japan could try their self-assessment according to the requirements of CTS. As a result, we realized that self-assessment by CTS is difficult unless we understand the fundamental concepts behind CTS. Hence the SIG started to create documents for understanding CTS, and this grew into the main activity of the SIG. Then, after intensive discussion, the focus of the activitiy has shifted to creating the data repository guideline that takes consideration of not only CTS but also data utilization.

2. Data Repository Guideline

Data repository guideline we are creating now is referring to 16 requirements of CTS, but is not its direct translation and has a unique structure proposed by JDARN. Rethinking of CTS has started by the item-based organization of CTS proposed by Mr. Shigeru Yatsuzuka at National Bioscience Database Center (NBDC). In the review process of CTS, the creation and publication of many types of documents is considered as an evidence of transparency. From the analysis of actual applications accepted by CTS and the type of documents mentioned therein, we can identify next actions to prepare necessary documents for CTS. In other words, we may be able to create an easier-to-understand guideline by converting abstract descriptions of CTS into concrete entities such as people and documents.

However, we also realized that itemizing people involved in data repositories is more difficult than itemizing documents. What kind of jobs do we need in data repositories, and who should be in charge of

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them? We also have a problem of naming; namely how those experts should be called. People proposed many new names for data experts, such as data librarian, data curator, data scientist, data engineer, and so on, but the actual meaning of those words are different from person to person. We need to organize the concept of jobs, and demonstrate their long-term career paths; otherwise, open science based on data repositories has uncertain future. We still do not have a solid model for this issue, and we are still in discussion.

3. Future directions

Since the establishment of JDARN, we have had active discussions in meetings held roughly every month. We believe that, as more data repositories join the discussion, we have more data repositories in Japan which are high quality, show more presence in the world, and has greater value as the infrastructure of open science. To realize this goal, data repositories should be considered as indispensable entity in the research. The main focus of CTS is to improve the trustworthiness and sustainability of data repositories as the container of data, but we also need experts for utlizing the content of data such as data integration, data analysis, data visualization and societal impact. A single organization is difficult to take care of all the tasks, so collaboration among data repositories will also be an important issue, and this is where network of data repositories can play an important role.

Keywords: Japan Data Repository Network, Data repository, Trustworthiness , CoreTrustSeal, Guideline, Data expert

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Data Sharing and Open Science: Practice, Expectation, Transparency, and Credit

*Shelley Stall[1]

1. American Geophysical Union

The data that underpins our research is a valuable part of the research process. Determining what data is needed in order to analyze the scientific question at hand is a critical part of our work. That data has incredible value to those interested in our research and building upon it.

Research data is best preserved in a trusted digital repository with robust descriptive information. Attribution and credit for data created, used, and reused is an important part of encouraging researchers to share their data and make it available to others. Including persistent, unique, global identifiers for the researchers that created the data as well as the links to associated publications where the data is cited allows us to discover, understand, and increase the possibly of that data being reused for new research in the future.

Within the Earth, space, and environmental sciences a large community of stakeholders has come together to require that data supporting a publication be placed in a trusted repository and properly cited in the publication. Many journals are now transitioning to this requirement and more are joining every day.

The infrastructure is being solidified to give creators of data the attribution and credit that recognizes the importance of the contribution to the scientific record for possible reuse in the future. Making data more findable, accessible, interoperable, and reusable (FAIR) is an important step towards more open science. We will describe what is expected by the Enabling FAIR Data project and the value of attribution and credit in encouraging researchers to share their data.

Keywords: FAIR Data, Trusted Repository, Data Sharing, Data Credit, ORCID, Persistent Identifier

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Ethical issues in open science

*Yasuhisa Kondo[1]

1. Research Institute for Humanity and Nature

This paper discusses ethical equity in open science as an emerging issue in promoting civic participatory science for social issues. Open science is understood as a conceptual complex of top-down policies and bottom-up actions. The bottom-up actions are represented by citizen science, wherein non-expert civil actors provide data or participate in fieldwork. Civic participatory science is becoming popular around the world, yet it does have an issue with ethical inequity in it. When holding a civic participatory workshop, such as an *ideathon*to co-create solutions for a given social issue, organizers, such as research experts or governmen agents, invite civic participants so that they can exploit their labor, knowledge, and ideas. Organizers give low, fixed-rate rewards and some entertainment in exchange. In my actual experience, some participants found this to be unbalanced and unfair. A detailed investigation revealed that incentives for researchers, including academic publication and promotion, would not be applicable to civic volunteers because they have different motivations. Even though it is voluntary, this work should be properly acknowledged. I would like to explore and discuss this ethical issue with participants in the Open Science international session.

Keywords: open science, ethical equity

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The perspective of Open Science with consideration of the gap between the Integrated Innovation Strategy and the current state of scholarly communication

*Kazuhiro Hayashi[1]

1. National Institute of Science and Technology Policy

Author introdces the Integrated Innovation Strategy as the latest documment which includes Open Science policy. It aims to develop the source of innovation or knowledge base for innovation with several data platforms including research data platofom of managing, sharing, and distributing data. On the other hand, some new evolutons occur in the scholarly publishing such as preprint servier, open research platform and registered report, which affects researchers directly, but not directly to connect to the research data platform. Author discusses the gap between them to find a way to transform Science as Open Science policy indicates.

Keywords: Open Science, Integrated Innovation Strategy, Research Data Platform, Scholarly publishing

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Future evolution of open archives for preprints, posters, and presentations as a key component of open science in the Earth and space sciences

*Brooks Hanson[1]

1. American Geophysical Union

A culture of using preprint servers has been widely established in astronomy, physics, computer sciences, and the social sciences for several decades. Studies of these have shown that sharing of manuscripts on these servers accelerates citations and the pace of science. Further alignment and standardization around this process, and broad cultural adoption would help accelerate these benefits. Servers have been established in other disciplines more recently, and usage has been growing gradually.

Use of preprint servers was slow to catch on in most of the Earth and space sciences, except for disciplines closely aligned with physics and astronomy, although most of the EGU journals are open-review journals and act in many ways like preprint servers. Two open archives were established for the Earth and space sciences in 2017: http://ESSOAr.org and http://EarthArxiv.org. ESSOAr (Earth and Space Science open Archive) was one of the first major archives to include posters presented at meetings. Uptake of both has been growing gradually; about 5% of posters presented at the 2018 Fall AGU meeting were posted on ESSOAr. Several are also including links to data sets or other resources (e.g., e-posters). Deposition was accelerated by automatic transfer of metadata from the meeting abstract system. Similar automated transfer is nearly implemented from major editorial systems for ESSOAr, BioArxiv and several others servers. This process should accelerate uptake and cultural adoption. Further adoption of standards by the broader community would further help adoption, including permission and encouragement from most journals, citation and credit standards, regularly connecting preprints with ORCID and later publications, broader awareness and adoption of standards on sharing code, data, and samples, and expansion to include oral presentations at meetings as technology improves to include audio and capture presentation information regularly. Support open science by adopting these best practices and archive your posters and draft manuscripts.

Keywords: Preprints, Open Science, Sharing Data

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[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | 302 3F

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), Chairperson:Shelley Stall(American Geophysics Union)

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After the JpGU-AGU Great Debate "Role of open data and open science in Geoscience" in JpGU Annual Meeting 2018 and a follow-up session in the AGU Fall Meeting 2018, this session reviews the current broad spectrum of Open Science in an international context. The session welcomes a wide range of papers and posters covering (but not limited to) open research data, open source licenses, data papers and journals, data repository, data sharing infrastructures and platforms, citizen science, crowdsourcing, crowdfunding, transdisciplinary research, capacity building, international networking, and deployment in earth and planetary sciences.

10:45 AM - 11:00 AM JST | 1:45 AM - 2:00 AM UTC

[MGI31-07] Cloud Computing Needs for Earth Observation Data Analysis: EGI and the European Open Science Cloud

★Invited Papers

Björn Backeberg[1], Yin Chen[1], *Tiziana Ferrari[1], Pedro Gonçalves[4], Paolo Mazzetti[3], Anabela Oliveira[2], Diego Scardaci[1], Gergely Sipos[1] (1.EGI Foundation, 2.LNEC, 3.CNR, 4.Terradue)

11:00 AM - 11:15 AM JST | 2:00 AM - 2:15 AM UTC

[MGI31-08] Open third generation geostationary satellites accelerate environmental studies: Case studies of CEReS, Chiba University, Japan

*Atsushi Higuchi[1,3], Koichi Toyoshima[1], Hitoshi Hirose[1], Hideaki Takenaka[2,1] (1.Center for Environmental Remote Sensing (CEReS), Chiba University, Japan, 2.EORC, JAXA, 3.NICT)

11:15 AM - 11:30 AM JST | 2:15 AM - 2:30 AM UTC

[MGI31-09] Scientific data chain for better data publication and preservation

*Takeshi Horinouchi[1] (1.Faculty of Environmental Earth Science, Hokkaido University)

11:30 AM - 11:45 AM JST | 2:30 AM - 2:45 AM UTC

[MGI31-10] Current status and problems of geodetic observation data distribution

*Toshimichi Otsubo[1], Yusuke Yokota[2], Tadashi Ishikawa[3], Mamoru Sekido[4], Takayuki Miyazaki[5], Shinobu Kurihara[5] (1.Hitotsubashi University, 2.Institute of Industrial Science, the University of Tokyo, 3.Hydrographic and Oceanographic Department, Japan Coast Guard, 4.National Institute of Information and Communications Technology, 5.Geospatial Information Authority of Japan)

11:45 AM - 12:00 PM JST | 2:45 AM - 3:00 AM UTC

[MGI31-11] Recent activity of data publication and data citation in the international community of geomagnetism

*Masahito Nose[1], Yasuhiro Murayama[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Strategic Program Produce Office, National Institute for Information Communications

Technology)

12:00 PM - 12:15 PM JST | 3:00 AM - 3:15 AM UTC

[MGI31-12] IGSN: International Collaboration Makes Samples and Sample Data FAIR

*Kerstin Lehnert[1], Jens Klump[2], Lesley Wyborn[3], Sarah Ramdeen[4] (1.Columbia University, 2.CSIRO Kensington, Australia, 3.Australian National University, Canberra, Australia, 4.Ronin Institute, USA)

Cloud Computing Needs for Earth Observation Data Analysis: EGI and the European Open Science Cloud

Björn Backeberg[1], Yin Chen[1], *Tiziana Ferrari[1], Pedro Gonçalves[4], Paolo Mazzetti[3], Anabela Oliveira[2], Diego Scardaci[1], Gergely Sipos[1]

1. EGI Foundation, 2. LNEC, 3. CNR, 4. Terradue

Over recent years, the vision of Open Science has emerged as a new paradigm of transparent, data-driven science capable of accelerating competitiveness and innovation. The embodiment of this vision in Europe is the European Open Science Cloud (EOSC), first proposed by the European Commission in April 2016 as part of the Communication on the ‘European Cloud Initiative’, one of the pillars of the Digital Single Market Strategy. The EOSC puts into practice the European vision for Open Innovation, Open Science and Open to the World by bringing together services and research products such as computing, storage, data, publications, software and workflows from national and international research infrastructures, research performing organisations, collaborations and projects.

Within EOSC and the EOSC-hub H2020 project, the European GEOSS community of the EuroGEOSS initiative, aims at demonstrating the benefit of Earth Observation for the society. Earth Observation data is being used to create the new knowledge needed to support informed decision-making for sustainable development and policy making. In addition, the GEOSS is contributing to EOSC by providing mediation and harmonisation services for accessing information and knowledge from in-situ and Earth Observation data, opening access to models for the generation of indicators.

EOSC will be instrumental in providing the large computation and storage capabilities needed to run scientific models at local, national, regional and potentially global scale. Within EOSC, EGI is the European digital infrastructure respondible for providing a distributed platform for scientific computing. The EGI Federation is the publicly funded e-infrastructure that brings together hundreds of data centres worldwide and also includes the largest community of research clouds in Europe with more than 20 cloud providers across 12 European countries offering IaaS cloud and storage services. The EGI cloud infrastructure is based on open standards allowing a seamless user experience over the cloud sites belonging to the federation through standardised interfaces. Advanced services are available to manage computing services and datasets in a distributed environment hiding the complexity of the geographical distribution to the developers of scientific applications and services.

The EGI Federated Cloud will give scientists the possibility to access and run analytic models in a transparent way, without the need of a local infrastructure hosting data and computing facilities. In this presentaiton, we will introduce the EGI technical solutions which provide the following capabilities: (1) the federation of services, data and resources; (2) the provision of geographically distributed large capacity computing resources and specialized computing facilities; (3) Jupyter notebooks data analysis capabilities integrated with federated Authentication and Authorization and the EGI Cloud; and (4) the support of added-value services, like the the OpenCoastS - for the production on-demand circulation forecast systems, the GEOSS Web Portal - for discovering and accessing GEOSS data from than 170 data systems globally, the Geohazards Thematic Exploitation Platform GEP - providing access to a set of on-demand terrain motion services supporting interferogram generation, co-seismic displacement mapping, landslide rapid mapping and landslide displacement field monitoring with Copernicus Sentinel-1 and Sentinel-2 data.

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Keywords: Open Science, EOSC, EGI, Earth observation data analysis

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Open third generation geostationary satellites accelerate environmental studies: Case studies of CEReS, Chiba University, Japan

*Atsushi Higuchi[1,3], Koichi Toyoshima[1], Hitoshi Hirose[1], Hideaki Takenaka[2,1]

1. Center for Environmental Remote Sensing (CEReS), Chiba University, Japan, 2. EORC, JAXA, 3. NICT

Geostationary satellites, such as well-known Himawari and GOES series, have advantages to capture the surface and the atmospheric status by relatively high-frequent scanning. Himawari-8/9 (Bessho et al., 2016) and GOES-R (Schmit et al., 2017) and GOES-S called as the third- generation geostationary satellites (3rd GEO) of which have capabilities of more-highly temporal scanning intervals (10 min. or 15min. in Full-Disk scan mode, 2.5 min. or 1 min. over target regions) with improved multiple spectral bands (16 bands). We will demonstrate possibility and capabilities by the utilizations of 3rd GEO data through our research and outreach activities, and we will show several research results through the open data policy of 3rd GEO. In addition, we will discuss potential and limitations for the acceleration of open science and contributions for the society.

References: Bessho et al., (2016): JMSJ, 94 (2), 151-183; Schmit et al., (2017): BAMS, 98, 681-698.

Keywords: Geostationary meteorological satellites, Environmental studies

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Scientific data chain for better data publication and preservation

*Takeshi Horinouchi[1]

1. Faculty of Environmental Earth Science, Hokkaido University

In this presentation, I will discuss some of the current issues and thoughts on data publication and preservation from the viewpoint of an atmospheric scientist in Japan. Earth observation data are not only experimental data but also are historical data, so their preservation and sharing are no less important than those from laboratory experiments. However, the current status is not satisfactory. I will introduce a way that might improve the situation.

In our field, we have “big” data and “small” data in two aspects. Data from big projects such as satellite observations, coordinated observations for weather forecast, climate prediction for IPCC are big in size and well preserved and shared. On the other hand, data from small projects such as field observations are not necessarily well-shared, and their preservation may be at risk. These longtail data are also important. For them, use of public or institutional data repository (and data journal) may be a solution, but to use it (them) is not yet our common conduct. More incentive and familiarity would be needed.

The other aspect of the big-and-small issue is on the level of process. For example, numerical values visualized in figures (such as line charts) in peer-reviewed papers can be regarded to be on a highest process level. They are normally small and derived from lower-level data, which can be big. This process is usually multi-staged, and to reproduce it is often difficult even when the original data are open.

Considering these issues, one can envision a digital scientific data chain (like food chain) in which research paper is on the top. Here, a plot in a figure is linked to a digital table (like CSV) stored in journal’s site. The table is further linked to a data repository content or a data paper (through which data repository can be linked). A well-organized data chain can realize reproducibility through documentation and digital operations. The latter can be helped by scripting. An example would be to script data screening and processing such as averaging. The data link in this chain can be multifold, starting from big low-level data.

This chain will make scientists familiar with data repository and data paper. It can also give incentive to write data paper to cite, so it can encourage documentation that increases the usability of data. It can also provide a good example of data usage. Therefore, it can promote data publication and preservation.

Keywords: data publication, open data

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Current status and problems of geodetic observation data distribution

*Toshimichi Otsubo[1], Yusuke Yokota[2], Tadashi Ishikawa[3], Mamoru Sekido[4], Takayuki Miyazaki[5], Shinobu Kurihara[5]

1. Hitotsubashi University, 2. Institute of Industrial Science, the University of Tokyo, 3. Hydrographic and Oceanographic Department, Japan Coast Guard, 4. National Institute of Information and Communications Technology, 5. Geospatial Information Authority of Japan

Geodetic technologies and geodetic data are now regarded as key infrastructure in the modern society. Space geodetic techniques such as GNSS, VLBI, SLR and DORIS totally rely on the global observation network, and therefore the 'service' organizations are formed under International Association of Geodesy to manage the international scientific/technological activities. Each service has its own data centres where the observation data and the analysis products are stored. Users can download them for free of charge.

Considering the fact that the worldwide institutes have spent a lot of expenses and efforts on the geodetic observations, we need to find a way to somehow reward them so that they can continue the operation or upgrade the system. One possibility for the future is the use of data DOI (Digital Object Identifier) which can be assigned to any style of data sets. When users publish their papers etc, they will be requested to cite the data DOI provided by each geodetic service in the reference section of their publication. By clicking the URL link, the readers can directly be guided to the landing page where the detailed description and contributors are given as well as the link to the data set. The data DOI scheme is expected to make the data providers more visible and even promote the usage of the data and the technology.

Early examples in sea-floor crustal deformation (Yokota et al., 2018, doi:10.1594/PANGAEA.885139), and a just-begun activity in GGOS (Global Geodetic Observing System) will be introduced.

Keywords: Geodesy, Space Geodesy, Navigation, GGOS, Data DOI

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Recent activity of data publication and data citation in the international community of geomagnetism

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Data-DOI (digital object identifier), data publication, and data citation will promote “Open Science”. Recognizing their importance, solar-terrestrial physics (STP) data centers in Japan have been working to mint DOI to their database. We participated from October 2014 in a 1-year pilot program for DOI-minting to science data launched by Japan Link Center, which is one of the DOI registration agencies. In the pilot program, a procedure of the DOI-minting for STP data was established. As a result of close collaboration with Japan Link Center, the first case of data-DOI in Japan (doi:10.17591/55838dbd6c0ad) was created in June 2015. As of February 2019, there are 18 data-DOIs for the STP data in Japan. Four of them are related to geomagnetic field data: the Dst index (doi:10.17593/14515-74000), the AE index (doi:10.17593/15031-54800), the Wp index (doi:10.17593/13437-46800), and magnetotelluric data at Muroto, Japan (doi:10.17593/13882-05900).

In the International Association of Geomagnetism and Aeronomy (IAGA), scientists who are working for data centers or observatories started discussion about DOI-minting to their data and a task force was formed in August 2013. In the latest IAGA assembly that was held at Cape Town in August 2017, the task force reported about "Present Status of DOI-minting to Geomagnetic Data/Indices" that is available from https://www.ngdc.noaa.gov/IAGA/vdat/. The report found that there are different types of activities of DOI-minting in individual data centers or observatories. In the field of geophysics including geomagnetism, interests to the DOI-minting are rapidly growing. At the next International Union Geodesy and Geophysics General Assemblies that will be held in Montreal, Canada, in July 2019, a joint session entitled “Geoscience data licensing, producing, publication and citation” is planned. This session solicits contributions presenting actual practices and future plans of data licensing, producing, publication, and citation of scientific data, and possible related topics. The international effort will be continued for DOI-minting to scientific data in geophysics.

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IGSN: International Collaboration Makes Samples and Sample Data FAIR

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In recent years, the International Geo Sample Number (IGSN) has seen increasing uptake as a Persistent Identifier (PID) for physical samples because there is growing recognition that unambiguous citation and tracking of physical samples allows previously impossible linking of samples to data and publications, linking and integration of sample-based observations across data systems, and paves the road toward advanced data mining of sample-based data. The IGSN leverages the existing Handle system as its technical basis, while following the example of DataCite for its governance structure and technical architecture.

The IGSN was originally developed for the solid Earth Sciences as a centralized system, but has evolved into an international PID system that is now adopted by a growing number and range of stakeholders worldwide, including researchers, collection curators, and data managers, and by other disciplines that need to refer to physical samples. More than 6.7 million samples have been registered so far.

The recent expansion of the IGSN beyond the geosciences confirms the power of its concept and implementation, but imposes substantial pressures on the existing capacity and capabilities of the IGSN architecture and its governing organization. Significant updates to the IGSN organizational and technical architecture are necessary at this point to keep pace with the growing demand and expectations. As stated by Wittenburg et al. [2017], *"in order to be useful and reliable, PID registration and resolution systems need to be trustworthy and sustainable"*. Essential criteria for trustworthiness include an organizational foundation that ensures longevity, sustainability, proper governance, and regular quality assessment of registration services, as well as a reliable and secure technical platform based on open standards that is sufficiently scalable and flexible to accommodate the growing diversity of specimen types, use cases, and stakeholder requirements.

A major planning activity is currently underway funded by a recent award from the Sloan Foundation with participation of an international group of experts to re-design and improve the existing organization and technical architecture of the IGSN for it to be able to respond to, and support in a sustainable manner, the rapidly growing demands of a global and increasingly multi-disciplinary user community in a landscape of maturing research data infrastructures. This will include a revision of the current business model of the IGSN e.V. as it is no longer able to sustain the organization through the necessary professionalization of its operations. The goal is to ensure that the IGSN will be a trustworthy, stable, and adaptable persistent identifier system for material samples, both technically and organizationally, that attracts, facilitates, and satisfies participation within and beyond the Geosciences, that will be a reliable component of the evolving research data ecosystem, and that is recognized as a trusted partner by data infrastructure providers and the science community alike.

Keywords: Research data , Samples, Persistent Identifier, FAIR

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[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_7

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University)

Open Science is growing up as a new research paradigm to accelerate scientific innovation. Deployed by ICSU-WDS (2008), G8 Open Data Charter (2013), deployment of Research Data Alliance (2013), OECD Global Science Forum's research projects (2016), and G7 Science Ministers' Communique (2017), it commonly refers to the top-down policies to make results of publicly-funded research freely available and accessible. On the other hand, this term also refers to the participatory bottom-up approaches such as citizen science, crowdfunding, and transdisciplinary research (Kitamoto 2016). It is noted that both approaches envision the transformation of research process to more findable, accessible, interoperable, and reusable one (Wilkinson et al. 2016).
After the JpGU-AGU Great Debate "Role of open data and open science in Geoscience" in JpGU Annual Meeting 2018 and a follow-up session in the AGU Fall Meeting 2018, this session reviews the current broad spectrum of Open Science in an international context. The session welcomes a wide range of papers and posters covering (but not limited to) open research data, open source licenses, data papers and journals, data repository, data sharing infrastructures and platforms, citizen science, crowdsourcing, crowdfunding, transdisciplinary research, capacity building, international networking, and deployment in earth and planetary sciences.

[MGI31-P01] Open Science, Community Science, and AGU’s Thriving Earth Exchange.

*Shelley Stall[1], Raj Pandya[1] (1.American Geophysical Union)

[MGI31-P02] RDUF (Research Data Utilization Forum): an arena for community discussion of international and regional research data sharing and management

Hideaki Takeda[2], *Yasuhiro Murayama[1], RDUF secretary office[3] (1.Strategic Program Produce Office, National Institute of Information and Communications Technology, 2.National Institute of Informatics, 3.Japan Science and Technology Agency)

[MGI31-P03] Query string-controlled web service for sharable and reproducible data visualization of earth, planetary and space sciences

*Koji Imai[1], Yasuhiro Murayama[1] (1.National Institute of Information and Communications Technology)

[MGI31-P04] Development of ground pipeline system for high-level scientific data products of the Hisaki satellite mission and its application to planetary space weather

*Tomoki Kimura[1], Atsushi Yamazaki[2], Kazuo Yoshioka[3], Go Murakami[2], Fuminori Tsuchiya[4], Hajime Kita[2], Chihiro Tao[5], Ichiro Yoshikawa[3], Atsushi Kumamoto[6], Yamauchi Chisato[7] (1.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Department of Complexity Science and Engineering, University of Tokyo, 4.Planetary Plasma and Atmospheric Research Center, Tohoku University, 5.National Institute of Information and Communications Technology, 6.Space and Terrestrial Plasma Physics Laboratory, Tohoku University, 7.Misato Observatory)

[MGI31-P05] Recent activities of the IUGONET for accelerating the integrated solar terrestrial science

*Shuji Abe[1], Yoshimasa Tanaka[2], Norio Umemura[3], Atsuki Shinbori[3], Satoru UeNo[4], Masahito Nose[3] (1.International Center for Space Weather Science and Education, Japan, 2.National Institute of Polar

Research, 3.Institute for Space-Earth Environmental Research, Nagoya University, 4.Kwasan & Hida Observatories, School of Science, Kyoto University)

[MGI31-P06] Attempt for Research Data Sharing and Citation in context of Open Science - Sharing Atmospheric MF Radar Observation Database as a Case Study

*Isoda Fusako[1], Yasuhiro Murayama[1], Koji Imai[1] (1.National Institute of Information and Communications Technology)

[MGI31-P07] A case example of sharing meteor radio observational data by small laboratory

*Yukinobu Koyama[1], Yusuke Miyanari[1] (1.National Institute of Technology, Oita College)

[MGI31-P08] Promotion of an Open-Science Activity of the Earth Science - Coordinated Observations and Data Analyses of meteor-associated Low-Frequency Radio Emission and Anomalous Hearing

*Takashi Watanabe[1] (1.ISC World Data System International Programme Office)

[MGI31-P09] Current status of minting DOIs for research data in JAMSTEC

*Kazuyo Fukuda[1], Hajime Kawakami[1], Tomoki Sasaki[1], Hiroki Horikawa[1], Hideaki Saito[1], Chizuru Saito[1], Sonoda Akira[1] (1.Japan Agency for Marine-Earth Science and Technology)

[MGI31-P10] Application of Web and GIS Technology to Develop Military's Differential Action Information Platform

*Chien Hao Chang[1], Ch Yu Liu[1], Chun Ta Wei[1] (1.Department of Computer Science and Information Engineering,CCIT)

Open Science, Community Science, and AGU’s Thriving Earth Exchange.

*Shelley Stall[1], Raj Pandya[1]

1. American Geophysical Union

Climate change, environmental degradation, and increased vulnerability to natural hazards place humanity, and the planet, in a precarious position. Science is necessary, but not sufficient, to addresses these challenges and chart a course to a sustainable future. Traditional models of scientific research need be augmented with new models of engagement and application that are more open, more transparent, and better connect scientific evidence, data, and ways of thinking to civic action.

One such model of engagement is community science, in which scientist and community leaders design and carry out scientific activities to advance community priorities. Thriving Earth Exchange, a five-year old program of the AGU, contributes to open science by advancing Community Science. Thriving Earth Exchange has launched over 90 community science projects all over the United States and world. Projects include working with community leaders to improve the carbon inventories so that cities can identify and mitigate emissions by sector or region and working with neighborhood residents to design rain gardens that prevent local flooding and sequester carbon. AGU is seeking to expand Thriving Earth Exchange internationally and advance the practice of community science around the world.

Drawing on experience in Thriving Earth Exchange, this poster will document the practices of successful community science projects. Successful projects involve partnership and shared decision making at every stage of the scientific process—from defining scientific questions, to deciding how and what data to collect, to applying new understanding to local issues. The most successful projects put scientific knowledge in a larger context and offer science with awareness of and respect for local decision processes. Community science, therefor, appreciates other ways of knowing and deciding, and never insists on the superiority of scientific perspectives. Finally, successful community science projects advance equity by providing a way for communities—especially communities who have been historically neglected, marginalized or oppressed—to help guide and use science to advance their priorities.
This poster will offer also offer scientists tips for doing community science- tips gleaned from AGU’s experience with the Thriving Earth Exchange. These tips involve practicing humility, being willing to balance research and application, attending to equity and power, and respecting local and community knowledge. Community science also requires a willingness to work across disciplines, to get comfortable with messy problems, and to apply systems perspectives. Some of the things that scientists bring to this work, in addition to the deep expertise, are their ability to frame problems, their ability to find and access scientific knowledge and data, and the professional and personal networks that come with being part of privileged institutions.

Keywords: Community Science, Open Science

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RDUF (Research Data Utilization Forum): an arena for community discussion of international and regional research data sharing and management

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1. Strategic Program Produce Office, National Institute of Information and Communications Technology, 2. National Institute of Informatics, 3. Japan Science and Technology Agency

Open Science and Research Data Sharing have been hot topics in international experts' discussions like in G8, OECD and AGU. Research Data Alliance (RDA) is the major arena for these topics and RDUF (Research Data Utilization Forum) has been set up inside Japan to make a local forum of Japanese experts and stakeholders. RDUF's individual membership is free of charge. We welcome your active participation in RDUF for research data discussions.

Keywords: research data management, open science

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Query string-controlled web service for sharable and reproducible data visualization of earth, planetary and space sciences

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We propose a new method for sharable and reproducible data visualization on a web browser. Reproducibility is one of the foundations of the scientific method. Reproducible evidence is imperative to build new scientific knowledge. Most natural scientists use figures, graphs, plots or diagrams to understand a phenomenon in detail. Therefore, information and communication technology for reproducible charts needs to promote scientific development. However, it is not easy especially for studies dealing with scientific data of different fields, because each data set is usually stored in a different place and a different format. For this reason, we have been building a web service, Cross-Cutting Comparisons (C3; Imai et al., 2018; doi/10.20637/JAXA-RR-17-009/0001; https://www.darts.isas.jaxa.jp/C3/).
One of the features of C3 is the interactive interface. By the inductive entry form, it is easy to make flexible charts of earth, planetary and space sciences on a web browser. C3 also has a query string (QS)-controllable system which includes information of data handling procedures in the QS in an orderly manner as follow:

(URL of CGI program)?(header)+(data selection)+(data extraction)+(option).

The QS consists of four parts separated by plusses (+): header, data selection, data extraction, and option. The information of data set and figure type is described in the data selection part. The information of data extraction is in the data extraction part. By explicitly showing the inputted setting in an orderly manner in the URL, it is easy to understand how the charts are made. User can make the charts by directly enter the QS in an address bar and also share the QS with text-based communication tools.

Keywords: open science, data visualization, sharable, reproducible, web service, query string

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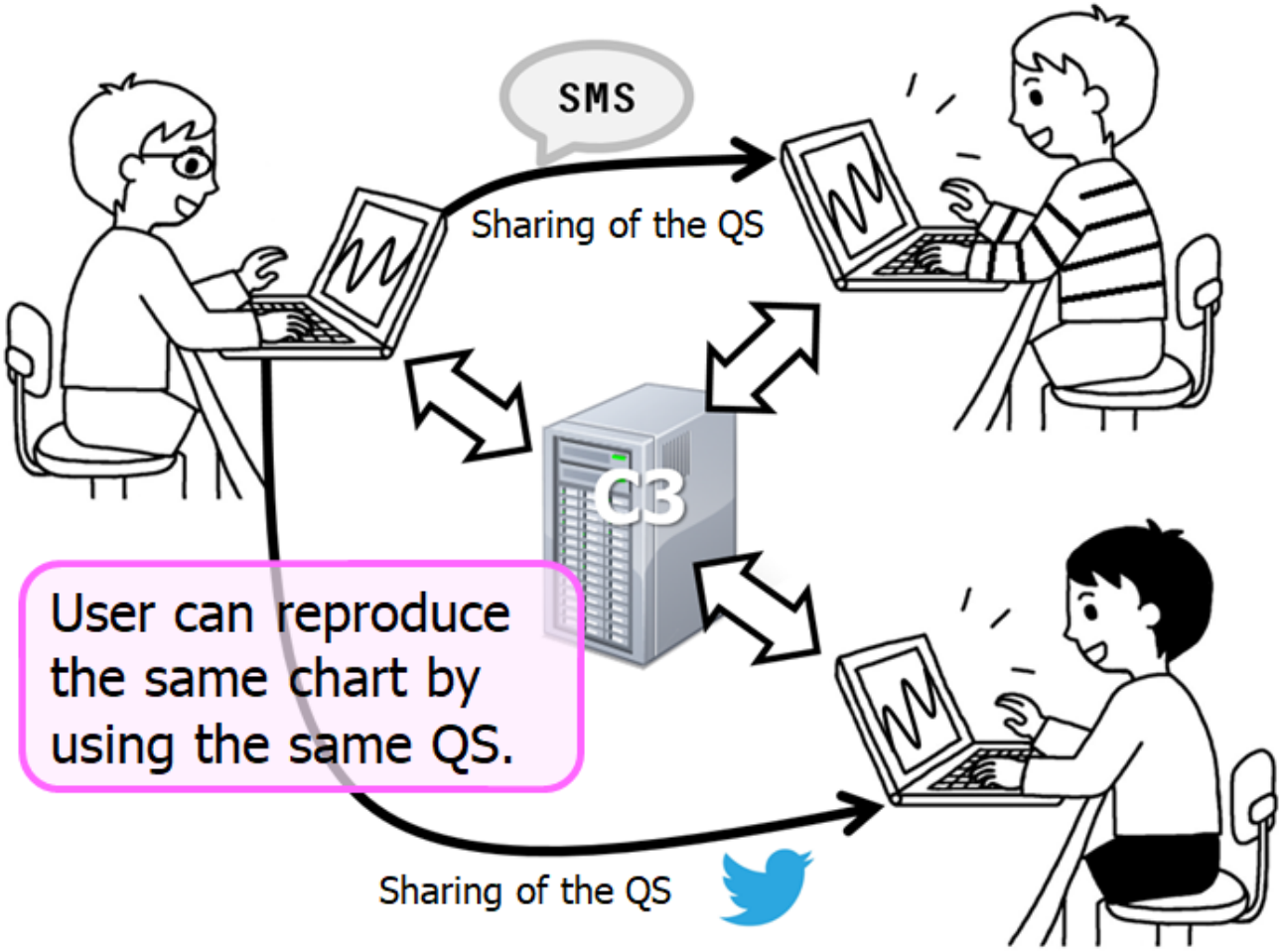

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Development of ground pipeline system for high-level scientific data products of the Hisaki satellite mission and its application to planetary space weather

*Tomoki Kimura[1], Atsushi Yamazaki[2], Kazuo Yoshioka[3], Go Murakami[2], Fuminori Tsuchiya[4], Hajime Kita[2], Chihiro Tao[5], Ichiro Yoshikawa[3], Atsushi Kumamoto[6], Yamauchi Chisato[7]

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The Hisaki satellite is the first-ever space telescope mission that is dedicated to planetary sciences. Atmospheres and magnetospheres of our solar system planets are continuously monitored by the extreme ultraviolet (EUV) spectrometer onboard Hisaki. Here we describe a data pipeline system developed for processing high-level scientific and ancillary data products of the Hisaki mission. The telemetry data downlinked from the satellite is stored in a ground telemetry database, processed to imaging spectral data with a 1-min temporal resolution and ancillary data products in the pipeline, and archived in a public database. The imaging spectra are further reduced to higher-level data products for practical scientific use. For example, light curves of the power emitted from Jupiter’ s aurora and plasma torus with a temporal resolution of 10 minutes are reduced from the imaging spectral data. The reduced light curve revealed transport process of energy and mass in Jupiter’ s magnetosphere and associated interplanetary solar wind conditions. The continuous monitoring with Hisaki largely contributes to understanding of space weather the planets in our solar system.

Keywords: Planetary Space Weather, Hisaki

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Recent activities of the IUGONET for accelerating the integrated solar terrestrial science

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The Inter-university Upper atmosphere Global Observation NETwork (IUGONET) is a scientific community by many Japanese institutes conducting observational research for upper atmosphere with 80km altitude and more. This region is a complex research field affected by both upper, for example solar radiations, and lower, for example atmospheric waves. Therefore, accelerating our science is not possible without data sharing infrastructures and platform for cross-sectional research. For the above reason, five Japanese institutes established IUGONET at 2009. IUGONET released many results for promoting the multidisciplinary research by using various kinds of data in the solar terrestrial science. IUGONET Type-A is a one-stop web service to provide data information (metadata) and visualization (quick look images and plots). Users can analysis data and make plots as you see on IUGONET Type-A by performing the indicated process on the analysis software, introduced below. UDAS (iUgonet Data Analysis Software) is a data analysis software written in Interactive Data Language (IDL). It works under SPEDAS (Space Physics Environment Data Analysis Software) as a plug-in. In addition, we developed program templates, called as UDAS egg (UDAS Easy Guide to Generate your load routines), for easily reading various kinds of data on SPEDAS. Users can easily load, analyze and visualize the data owned by each researcher by replacing a few codes (about 10 lines in total) marked on the template according to the instructions. This function is equipped to the latest version of the SPEDAS executables for users who do not own IDL licenses. It allows users to utilize data for interdisciplinary study, and supports the development of integrated solar terrestrial science. We also consider that it is one of our essential task for the future and development of the research field to develop both Japanese and foreign young researchers who can handle data easily. It is so difficult to accomplish it by only one project. Therefore, we holds many data analysis workshops each year in Japan and overseas countries in collaboration with other programs related to scientific research and data, for example ISELION, ISELLI, VarSITI, and WDS, etc. IUGONET developers join workshops and have lecture courses on these, and participants can practically learn how to get and analyze data. In last fiscal year, we held two times domestic lecture courses in Japan, and four international lecture courses in Malaysia, India, China, and Indonesia. The effects of this activity are very clear from the increase of scientific papers by using IUGONET products. In conclusion, Open Data activities of IUGONET mainly intend at the development of solar-terrestrial science, and make many scientific and educational results in our domain. We hope our activity will be helpful for other fields.

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Attempt for Research Data Sharing and Citation in context of Open Science - Sharing Atmospheric MF Radar Observation Database as a Case Study

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1. National Institute of Information and Communications Technology

Research Data Sharing is one element that constitutes Open Science. In recent discussion, it is said that scientists should share data that they collect and/or generate, to allow free and open access [1)].

Scientific data sharing are often carried out for responding to requests by funding agencies to open research data, for raising the transparency and fairness of research, for validation of research results, for increasing new research opportunities using shared data from multi-domains and interdisciplinary fields, and for increasing recognition of and rewarding achievement of scientists and experts of data management and publication [2)].

It is being promoted to cite research data like citing other articles in a research paper[3)]. When the data is cited, the DOI (Digital Object Identifier) is becoming to be used widely[4)]. Minting DOIs to a research paper or document is prevailing already. In the examples of data citations, the data is increasingly often cited with its DOI in the acknowledgement or the reference of a paper[5)]. It is expected that recognition of data creators, providers, curators, and managers will increase with help of data DOI through automatic surveillance of cited data DOIs on Internet [6)].

We are preparing sharing on a Web site of the neutral wind data observed with MF (Medium Frequency) radars at Wakkanai (45.36N, 141.81E) and Yamawaga (31.20N, 130.62E) of Japan. The 30 min. averaged data will be provided which is useful with increased confidence to analyze atmospheric dynamical phenomena (Original time interval of the observation are 3-4 min.). Currently FAIR data principle (Findable, Accessible, Interoperable and Re-usable) [7)] is being discussed to be a preferable condition for research data sharing. We are trying to increase FAIR-principle compliance level of the MF Radar data. Currently the data is: described in ASCII text format (difficult to lose readability if a human reads the data file), including the simple description in each data field in the file (although technical terms need to be improved since some are not very intelligible like "AVERAGED VELOCITY" "DATA COUNT” are to be , simpler HTML page having static URLs (dynamic data/web page generation can be a barrier for citability of online data objects). Minting the DOI is being planned.

In future, of open science activity, it is thought that research data sharing will become an important "building block" for researchers and stakeholders. This experiment in the present paper is a case study of simple data sharing, which is expected to lead to a case study for helping development of a research data sharing framework, our target is that what we will learn from this study will contribute to knowledge and techniques more universally adaptable to other data sharing practices in future.

Keywords: Research Data Sharing, Digital Object Identifier, Mesosphere and Lower Thermosphere

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A case example of sharing meteor radio observational data by small laboratory

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1. National Institute of Technology, Oita College

As a result of being ionized by the meteor, the ionospheric electrical conductivity increases so much as to reflect the 50MHz radio waves which penetrates the ionosphere usually. We have been observing it in Oita of Japan for two years. However, there is not much information on the ionosphere obtained from one observatory. How to share data with other groups become the key in order to construct multipoint observation network to investigate the ionosphere in detail. In this presentation, we show a case example of data sharing, aware of FAIR principles, by using Google Drive with Google Apps Scripts.

Keywords: Meteor radio observation, Data sharing, Metadata, Image processing, Deep learning

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Promotion of an Open-Science Activity of the Earth Science - Coordinated Observations and Data Analyses of meteor-associated Low-Frequency Radio Emission and Anomalous Hearing

*Takashi Watanabe[1]

1. ISC World Data System International Programme Office

In the Open Science era, collaborations between researchers and citizens are strongly endorsed, but selection of a “good” project will be essential to involve many citizen scientists. Simultaneously audible “sounds” associated with the flight of very bright meteors (fireballs) have been reported by many people including citizens and researchers in many years, even in the modern science era. Keay (1980, 1992) proposed that the anomalous hearing is caused by the very strong radio emission from fireball at very low frequencies, mainly in the ELF/VLF region. Although the mechanism of the proposed strong radio emission is sensed as “sound” is unknown, the detection of very low-frequency radio noise from fireballs will be a challenging research objective in the field of earth science because many fireballs are observed in the lower ionosphere at the altitudes between 80 to 120 km. The first detection of the meteor-associated VLF radio emission was reported by Watanabe et al. (1988) for a -6 mag Perseid fireball appeared at about 03:53:41 (JST), 13 August 1981, as a burst-like VLF emission with peculiar spectral characteristics. Since the discovery, several papers on observations of meteor-associated VLF radio emission in the period of prominent meteoric showers but one-to-one connections with individual meteors were not made and distinction from ordinal spherices (e.g. radio pulses caused by lightning activity) were not clearly examined. We are planning to perform a research program between researchers and citizen scientists in Japan involving optical, radio, and Video observers for prominent meteoric showers. The Perseid appearing every year in the mid of August will be the best target because many observational groups of universities and high schools and Video observers will be involved to this project. We will collaborate with members of Japan Meteor Society to assemble and archive observational data. We will also to correct reports of anomalous hearing of meteoric sound from observes. This project will be organized by T. Watanabe (WDS-IPO, NICT), H. Oya (Chiba Univ.), K. Shiokawa (ISEE, Nagoya Univ.), Y. Kato (ISEE, Nagoya Univ.) and K. Suzuki (Nippon Meteor Sciety).

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Keywords: Open Science, Meteoric Radio Emission, Meteoric Anomalous Hereing

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Current status of minting DOIs for research data in JAMSTEC

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1. Japan Agency for Marine-Earth Science and Technology

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has collected information of several precedent examples to clarify effective data Digital Object Identifier (DOI) workflow since 2015, and started to assign DOI to an oceanographic research data in 2017. In JpGU2018, we introduced development of the Data DOI Management System to manage DOI metadata and generate landing pages. We will report the current status including following topics in this presentation.

- Functional enhancement for related database
The Data and Sample Research System for Whole Cruise Information (DARWIN) disseminates information of research cruise, dive, observation data and samples obtained by JAMSTEC's research vessels and submersibles. DARWIN has been enhanced to allow linkage of DOI metadata with the Data DOI Management System via Web API to achieve effective DOI maintenance for a large amount of content.

- Survey of DOI for research data
A wide variety of databases depending on the disciplines, research project, and types of data are disseminated by several departments and groups within JAMSTEC. Therefore, a survey of minting DOI for research data is being conducted to grasp data creators' needs. We extracted the target databases from catalog metadata published in JAMSTEC data catalog. The questions in this survey ask about ownership of data, conditions for data usage, granularity of DOI assignment, and continuity of database services.

The first edition of guidelines for minting DOIs for research data in JAMSTEC will be developed based on the practical operation of systems and the survey results by the end of the year 2019.

Related URLs
JAMSTEC Data DOI, http://www.jamstec.go.jp/datadoi/doi/10.17596/e/about.html
DARWIN, http://www.godac.jamstec.go.jp/darwin/e
JAMSTEC data catalog, http://www.godac.jamstec.go.jp/catalog/data_catalog/e/

Keywords: open science, open research data, DOI

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Application of Web and GIS Technology to Develop Military's Differential Action Information Platform

*Chien Hao Chang[1], Ch Yu Liu[1], Chun Ta Wei[1]

1. Department of Computer Science and Information Engineering,CCIT

Taiwan is located in a special environment where geographical location and plate transfer, rainfall and earthquakes occur frequently, geological disasters are diverse and complex, and disaster prevention is an important issue that cannot be evaded by the whole people. In the face of such frequent natural disasters, the government’ s disaster prevention and relief work is particularly important.
On July 13, 1999, the Legislative Yuan officially read the "Disaster Prevention Act" [1] sub-amendment amendment, which not only allowed the Fire Department to transform into a disaster prevention and rescue department, but also assigned the national army to prevent disasters. Source of law. In keeping with the "disaster relief as a warfare" attitude, the National Army can, in response to each exercise and drill, be able to give full play to the rapid relief efforts of the national army in the golden rescue moment of major disasters, and avoid the national social disaster caused by environmental safety issues. The National Army has followed the policy guidance of "advance deployment, pre-set strength, and always-time rescue" for disaster relief, and is on standby to carry out disaster prevention and rescue missions such as preventive evacuation to protect the lives and property of the people.
To construct a multi-disaster information platform from the forward-looking command post to the users of the various levels of command posts at the back-end, to provide real-time information on the disaster relief center, to facilitate the disaster, and to control and issue orders through the information platform. For the officers and men, the mission is smooth and the delivery time is shortened. After the National Army has been refined, the number of people has been greatly reduced. In the future, in the implementation of disaster prevention, it is necessary to integrate and properly use the resources of the entire army to meet the needs of the people.

Keywords: disaster relief, military, information platform

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[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_43

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University)

Open Science is growing up as a new research paradigm to accelerate scientific innovation. Deployed by ICSU-WDS (2008), G8 Open Data Charter (2013), deployment of Research Data Alliance (2013), OECD Global Science Forum's research projects (2016), and G7 Science Ministers' Communique (2017), it commonly refers to the top-down policies to make results of publicly-funded research freely available and accessible. On the other hand, this term also refers to the participatory bottom-up approaches such as citizen science, crowdfunding, and transdisciplinary research (Kitamoto 2016). It is noted that both approaches envision the transformation of research process to more findable, accessible, interoperable, and reusable one (Wilkinson et al. 2016).
After the JpGU-AGU Great Debate "Role of open data and open science in Geoscience" in JpGU Annual Meeting 2018 and a follow-up session in the AGU Fall Meeting 2018, this session reviews the current broad spectrum of Open Science in an international context. The session welcomes a wide range of papers and posters covering (but not limited to) open research data, open source licenses, data papers and journals, data repository, data sharing infrastructures and platforms, citizen science, crowdsourcing, crowdfunding, transdisciplinary research, capacity building, international networking, and deployment in earth and planetary sciences.

[MGI31-P01] Open Science, Community Science, and AGU’s Thriving Earth Exchange.

*Shelley Stall[1], Raj Pandya[1] (1.American Geophysical Union)

[MGI31-P02] RDUF (Research Data Utilization Forum): an arena for community discussion of international and regional research data sharing and management

Hideaki Takeda[2], *Yasuhiro Murayama[1], RDUF secretary office[3] (1.Strategic Program Produce Office, National Institute of Information and Communications Technology, 2.National Institute of Informatics, 3.Japan Science and Technology Agency)

[MGI31-P03] Query string-controlled web service for sharable and reproducible data visualization of earth, planetary and space sciences

*Koji Imai[1], Yasuhiro Murayama[1] (1.National Institute of Information and Communications Technology)

[MGI31-P04] Development of ground pipeline system for high-level scientific data products of the Hisaki satellite mission and its application to planetary space weather

*Tomoki Kimura[1], Atsushi Yamazaki[2], Kazuo Yoshioka[3], Go Murakami[2], Fuminori Tsuchiya[4], Hajime Kita[2], Chihiro Tao[5], Ichiro Yoshikawa[3], Atsushi Kumamoto[6], Yamauchi Chisato[7] (1.Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 2.Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3.Department of Complexity Science and Engineering, University of Tokyo, 4.Planetary Plasma and Atmospheric Research Center, Tohoku University, 5.National Institute of Information and Communications Technology, 6.Space and Terrestrial Plasma Physics Laboratory, Tohoku University, 7.Misato Observatory)

[MGI31-P05] Recent activities of the IUGONET for accelerating the integrated solar terrestrial science

*Shuji Abe[1], Yoshimasa Tanaka[2], Norio Umemura[3], Atsuki Shinbori[3], Satoru UeNo[4], Masahito Nose[3] (1.International Center for Space Weather Science and Education, Japan, 2.National Institute of Polar

Research, 3.Institute for Space-Earth Environmental Research, Nagoya University, 4.Kwasan & Hida Observatories, School of Science, Kyoto University)

[MGI31-P06] Attempt for Research Data Sharing and Citation in context of Open Science - Sharing Atmospheric MF Radar Observation Database as a Case Study

*Isoda Fusako[1], Yasuhiro Murayama[1], Koji Imai[1] (1.National Institute of Information and Communications Technology)

[MGI31-P07] A case example of sharing meteor radio observational data by small laboratory

*Yukinobu Koyama[1], Yusuke Miyanari[1] (1.National Institute of Technology, Oita College)

[MGI31-P08] Promotion of an Open-Science Activity of the Earth Science - Coordinated Observations and Data Analyses of meteor-associated Low-Frequency Radio Emission and Anomalous Hearing

*Takashi Watanabe[1] (1.ISC World Data System International Programme Office)

[MGI31-P09] Current status of minting DOIs for research data in JAMSTEC

*Kazuyo Fukuda[1], Hajime Kawakami[1], Tomoki Sasaki[1], Hiroki Horikawa[1], Hideaki Saito[1], Chizuru Saito[1], Sonoda Akira[1] (1.Japan Agency for Marine-Earth Science and Technology)

[MGI31-P10] Application of Web and GIS Technology to Develop Military's Differential Action Information Platform

*Chien Hao Chang[1], Ch Yu Liu[1], Chun Ta Wei[1] (1.Department of Computer Science and Information Engineering,CCIT)

Open Science, Community Science, and AGU’s Thriving Earth Exchange.

*Shelley Stall[1], Raj Pandya[1]

1. American Geophysical Union

Climate change, environmental degradation, and increased vulnerability to natural hazards place humanity, and the planet, in a precarious position. Science is necessary, but not sufficient, to addresses these challenges and chart a course to a sustainable future. Traditional models of scientific research need be augmented with new models of engagement and application that are more open, more transparent, and better connect scientific evidence, data, and ways of thinking to civic action.

One such model of engagement is community science, in which scientist and community leaders design and carry out scientific activities to advance community priorities. Thriving Earth Exchange, a five-year old program of the AGU, contributes to open science by advancing Community Science. Thriving Earth Exchange has launched over 90 community science projects all over the United States and world. Projects include working with community leaders to improve the carbon inventories so that cities can identify and mitigate emissions by sector or region and working with neighborhood residents to design rain gardens that prevent local flooding and sequester carbon. AGU is seeking to expand Thriving Earth Exchange internationally and advance the practice of community science around the world.

Drawing on experience in Thriving Earth Exchange, this poster will document the practices of successful community science projects. Successful projects involve partnership and shared decision making at every stage of the scientific process—from defining scientific questions, to deciding how and what data to collect, to applying new understanding to local issues. The most successful projects put scientific knowledge in a larger context and offer science with awareness of and respect for local decision processes. Community science, therefor, appreciates other ways of knowing and deciding, and never insists on the superiority of scientific perspectives. Finally, successful community science projects advance equity by providing a way for communities—especially communities who have been historically neglected, marginalized or oppressed—to help guide and use science to advance their priorities.
This poster will offer also offer scientists tips for doing community science- tips gleaned from AGU’s experience with the Thriving Earth Exchange. These tips involve practicing humility, being willing to balance research and application, attending to equity and power, and respecting local and community knowledge. Community science also requires a willingness to work across disciplines, to get comfortable with messy problems, and to apply systems perspectives. Some of the things that scientists bring to this work, in addition to the deep expertise, are their ability to frame problems, their ability to find and access scientific knowledge and data, and the professional and personal networks that come with being part of privileged institutions.

Keywords: Community Science, Open Science

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RDUF (Research Data Utilization Forum): an arena for community discussion of international and regional research data sharing and management

Hideaki Takeda[2], *Yasuhiro Murayama[1], RDUF secretary office[3]

1. Strategic Program Produce Office, National Institute of Information and Communications Technology, 2. National Institute of Informatics, 3. Japan Science and Technology Agency

Open Science and Research Data Sharing have been hot topics in international experts' discussions like in G8, OECD and AGU. Research Data Alliance (RDA) is the major arena for these topics and RDUF (Research Data Utilization Forum) has been set up inside Japan to make a local forum of Japanese experts and stakeholders. RDUF's individual membership is free of charge. We welcome your active participation in RDUF for research data discussions.

Keywords: research data management, open science

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Query string-controlled web service for sharable and reproducible data visualization of earth, planetary and space sciences

*Koji Imai[1], Yasuhiro Murayama[1]

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We propose a new method for sharable and reproducible data visualization on a web browser. Reproducibility is one of the foundations of the scientific method. Reproducible evidence is imperative to build new scientific knowledge. Most natural scientists use figures, graphs, plots or diagrams to understand a phenomenon in detail. Therefore, information and communication technology for reproducible charts needs to promote scientific development. However, it is not easy especially for studies dealing with scientific data of different fields, because each data set is usually stored in a different place and a different format. For this reason, we have been building a web service, Cross-Cutting Comparisons (C3; Imai et al., 2018; doi/10.20637/JAXA-RR-17-009/0001; https://www.darts.isas.jaxa.jp/C3/).
One of the features of C3 is the interactive interface. By the inductive entry form, it is easy to make flexible charts of earth, planetary and space sciences on a web browser. C3 also has a query string (QS)-controllable system which includes information of data handling procedures in the QS in an orderly manner as follow:

(URL of CGI program)?(header)+(data selection)+(data extraction)+(option).

The QS consists of four parts separated by plusses (+): header, data selection, data extraction, and option. The information of data set and figure type is described in the data selection part. The information of data extraction is in the data extraction part. By explicitly showing the inputted setting in an orderly manner in the URL, it is easy to understand how the charts are made. User can make the charts by directly enter the QS in an address bar and also share the QS with text-based communication tools.

Keywords: open science, data visualization, sharable, reproducible, web service, query string

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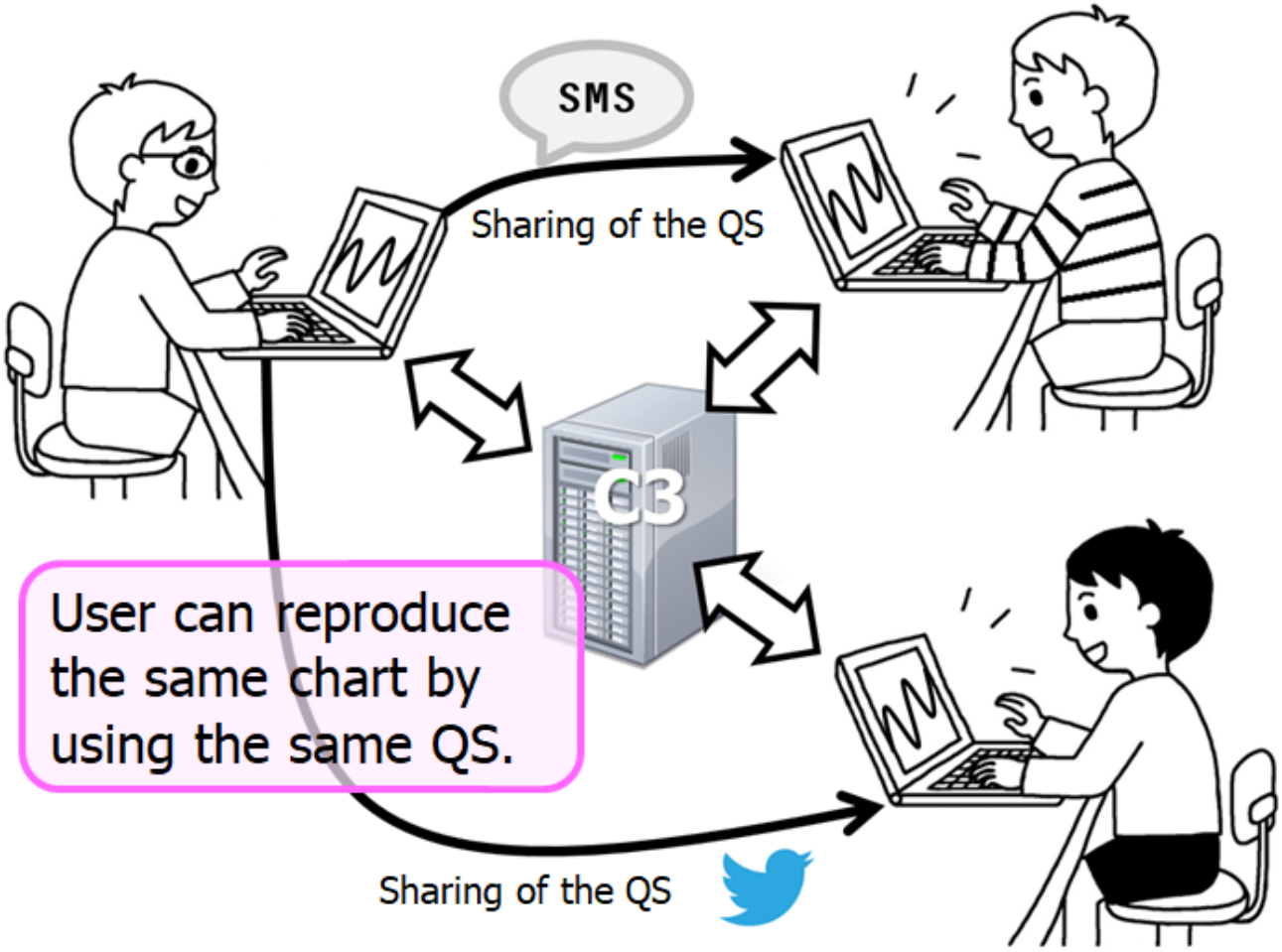

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Development of ground pipeline system for high-level scientific data products of the Hisaki satellite mission and its application to planetary space weather

*Tomoki Kimura[1], Atsushi Yamazaki[2], Kazuo Yoshioka[3], Go Murakami[2], Fuminori Tsuchiya[4], Hajime Kita[2], Chihiro Tao[5], Ichiro Yoshikawa[3], Atsushi Kumamoto[6], Yamauchi Chisato[7]

1. Frontier Research Institute for Interdisciplinary Sciences, Tohoku University, 2. Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3. Department of Complexity Science and Engineering, University of Tokyo, 4. Planetary Plasma and Atmospheric Research Center, Tohoku University, 5. National Institute of Information and Communications Technology, 6. Space and Terrestrial Plasma Physics Laboratory, Tohoku University, 7. Misato Observatory

The Hisaki satellite is the first-ever space telescope mission that is dedicated to planetary sciences. Atmospheres and magnetospheres of our solar system planets are continuously monitored by the extreme ultraviolet (EUV) spectrometer onboard Hisaki. Here we describe a data pipeline system developed for processing high-level scientific and ancillary data products of the Hisaki mission. The telemetry data downlinked from the satellite is stored in a ground telemetry database, processed to imaging spectral data with a 1-min temporal resolution and ancillary data products in the pipeline, and archived in a public database. The imaging spectra are further reduced to higher-level data products for practical scientific use. For example, light curves of the power emitted from Jupiter’ s aurora and plasma torus with a temporal resolution of 10 minutes are reduced from the imaging spectral data. The reduced light curve revealed transport process of energy and mass in Jupiter’ s magnetosphere and associated interplanetary solar wind conditions. The continuous monitoring with Hisaki largely contributes to understanding of space weather the planets in our solar system.

Keywords: Planetary Space Weather, Hisaki

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Recent activities of the IUGONET for accelerating the integrated solar terrestrial science

*Shuji Abe[1], Yoshimasa Tanaka[2], Norio Umemura[3], Atsuki Shinbori[3], Satoru UeNo[4], Masahito Nose[3]

1. International Center for Space Weather Science and Education, Japan, 2. National Institute of Polar Research, 3. Institute for Space-Earth Environmental Research, Nagoya University, 4. Kwasan & Hida Observatories, School of Science, Kyoto University

The Inter-university Upper atmosphere Global Observation NETwork (IUGONET) is a scientific community by many Japanese institutes conducting observational research for upper atmosphere with 80km altitude and more. This region is a complex research field affected by both upper, for example solar radiations, and lower, for example atmospheric waves. Therefore, accelerating our science is not possible without data sharing infrastructures and platform for cross-sectional research. For the above reason, five Japanese institutes established IUGONET at 2009. IUGONET released many results for promoting the multidisciplinary research by using various kinds of data in the solar terrestrial science. IUGONET Type-A is a one-stop web service to provide data information (metadata) and visualization (quick look images and plots). Users can analysis data and make plots as you see on IUGONET Type-A by performing the indicated process on the analysis software, introduced below. UDAS (iUgonet Data Analysis Software) is a data analysis software written in Interactive Data Language (IDL). It works under SPEDAS (Space Physics Environment Data Analysis Software) as a plug-in. In addition, we developed program templates, called as UDAS egg (UDAS Easy Guide to Generate your load routines), for easily reading various kinds of data on SPEDAS. Users can easily load, analyze and visualize the data owned by each researcher by replacing a few codes (about 10 lines in total) marked on the template according to the instructions. This function is equipped to the latest version of the SPEDAS executables for users who do not own IDL licenses. It allows users to utilize data for interdisciplinary study, and supports the development of integrated solar terrestrial science. We also consider that it is one of our essential task for the future and development of the research field to develop both Japanese and foreign young researchers who can handle data easily. It is so difficult to accomplish it by only one project. Therefore, we holds many data analysis workshops each year in Japan and overseas countries in collaboration with other programs related to scientific research and data, for example ISELION, ISELLI, VarSITI, and WDS, etc. IUGONET developers join workshops and have lecture courses on these, and participants can practically learn how to get and analyze data. In last fiscal year, we held two times domestic lecture courses in Japan, and four international lecture courses in Malaysia, India, China, and Indonesia. The effects of this activity are very clear from the increase of scientific papers by using IUGONET products. In conclusion, Open Data activities of IUGONET mainly intend at the development of solar-terrestrial science, and make many scientific and educational results in our domain. We hope our activity will be helpful for other fields.

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Attempt for Research Data Sharing and Citation in context of Open Science - Sharing Atmospheric MF Radar Observation Database as a Case Study

*Isoda Fusako[1], Yasuhiro Murayama[1], Koji Imai[1]

1. National Institute of Information and Communications Technology

Research Data Sharing is one element that constitutes Open Science. In recent discussion, it is said that scientists should share data that they collect and/or generate, to allow free and open access [1)].

Scientific data sharing are often carried out for responding to requests by funding agencies to open research data, for raising the transparency and fairness of research, for validation of research results, for increasing new research opportunities using shared data from multi-domains and interdisciplinary fields, and for increasing recognition of and rewarding achievement of scientists and experts of data management and publication [2)].

It is being promoted to cite research data like citing other articles in a research paper[3)]. When the data is cited, the DOI (Digital Object Identifier) is becoming to be used widely[4)]. Minting DOIs to a research paper or document is prevailing already. In the examples of data citations, the data is increasingly often cited with its DOI in the acknowledgement or the reference of a paper[5)]. It is expected that recognition of data creators, providers, curators, and managers will increase with help of data DOI through automatic surveillance of cited data DOIs on Internet [6)].

We are preparing sharing on a Web site of the neutral wind data observed with MF (Medium Frequency) radars at Wakkanai (45.36N, 141.81E) and Yamawaga (31.20N, 130.62E) of Japan. The 30 min. averaged data will be provided which is useful with increased confidence to analyze atmospheric dynamical phenomena (Original time interval of the observation are 3-4 min.). Currently FAIR data principle (Findable, Accessible, Interoperable and Re-usable) [7)] is being discussed to be a preferable condition for research data sharing. We are trying to increase FAIR-principle compliance level of the MF Radar data. Currently the data is: described in ASCII text format (difficult to lose readability if a human reads the data file), including the simple description in each data field in the file (although technical terms need to be improved since some are not very intelligible like "AVERAGED VELOCITY" "DATA COUNT” are to be , simpler HTML page having static URLs (dynamic data/web page generation can be a barrier for citability of online data objects). Minting the DOI is being planned.

In future, of open science activity, it is thought that research data sharing will become an important "building block" for researchers and stakeholders. This experiment in the present paper is a case study of simple data sharing, which is expected to lead to a case study for helping development of a research data sharing framework, our target is that what we will learn from this study will contribute to knowledge and techniques more universally adaptable to other data sharing practices in future.

Keywords: Research Data Sharing, Digital Object Identifier, Mesosphere and Lower Thermosphere

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A case example of sharing meteor radio observational data by small laboratory

*Yukinobu Koyama[1], Yusuke Miyanari[1]

1. National Institute of Technology, Oita College

As a result of being ionized by the meteor, the ionospheric electrical conductivity increases so much as to reflect the 50MHz radio waves which penetrates the ionosphere usually. We have been observing it in Oita of Japan for two years. However, there is not much information on the ionosphere obtained from one observatory. How to share data with other groups become the key in order to construct multipoint observation network to investigate the ionosphere in detail. In this presentation, we show a case example of data sharing, aware of FAIR principles, by using Google Drive with Google Apps Scripts.

Keywords: Meteor radio observation, Data sharing, Metadata, Image processing, Deep learning

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Promotion of an Open-Science Activity of the Earth Science - Coordinated Observations and Data Analyses of meteor-associated Low-Frequency Radio Emission and Anomalous Hearing

*Takashi Watanabe[1]

1. ISC World Data System International Programme Office

In the Open Science era, collaborations between researchers and citizens are strongly endorsed, but selection of a “good” project will be essential to involve many citizen scientists. Simultaneously audible “sounds” associated with the flight of very bright meteors (fireballs) have been reported by many people including citizens and researchers in many years, even in the modern science era. Keay (1980, 1992) proposed that the anomalous hearing is caused by the very strong radio emission from fireball at very low frequencies, mainly in the ELF/VLF region. Although the mechanism of the proposed strong radio emission is sensed as “sound” is unknown, the detection of very low-frequency radio noise from fireballs will be a challenging research objective in the field of earth science because many fireballs are observed in the lower ionosphere at the altitudes between 80 to 120 km. The first detection of the meteor-associated VLF radio emission was reported by Watanabe et al. (1988) for a -6 mag Perseid fireball appeared at about 03:53:41 (JST), 13 August 1981, as a burst-like VLF emission with peculiar spectral characteristics. Since the discovery, several papers on observations of meteor-associated VLF radio emission in the period of prominent meteoric showers but one-to-one connections with individual meteors were not made and distinction from ordinal spherices (e.g. radio pulses caused by lightning activity) were not clearly examined. We are planning to perform a research program between researchers and citizen scientists in Japan involving optical, radio, and Video observers for prominent meteoric showers. The Perseid appearing every year in the mid of August will be the best target because many observational groups of universities and high schools and Video observers will be involved to this project. We will collaborate with members of Japan Meteor Society to assemble and archive observational data. We will also to correct reports of anomalous hearing of meteoric sound from observes. This project will be organized by T. Watanabe (WDS-IPO, NICT), H. Oya (Chiba Univ.), K. Shiokawa (ISEE, Nagoya Univ.), Y. Kato (ISEE, Nagoya Univ.) and K. Suzuki (Nippon Meteor Sciety).

Keay C. S. L., Anomalous Sounds from the Entry of Meteor Fireballs, Science, Vol. 210, 11-15, 1980.

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Keay, C. S. L., Asteroids, Comets, Meteors 1991, Lunar and Planetary Institute, Houston, 297 300, 1992

Keywords: Open Science, Meteoric Radio Emission, Meteoric Anomalous Hereing

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Current status of minting DOIs for research data in JAMSTEC

*Kazuyo Fukuda[1], Hajime Kawakami[1], Tomoki Sasaki[1], Hiroki Horikawa[1], Hideaki Saito[1], Chizuru Saito[1], Sonoda Akira[1]

1. Japan Agency for Marine-Earth Science and Technology

Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has collected information of several precedent examples to clarify effective data Digital Object Identifier (DOI) workflow since 2015, and started to assign DOI to an oceanographic research data in 2017. In JpGU2018, we introduced development of the Data DOI Management System to manage DOI metadata and generate landing pages. We will report the current status including following topics in this presentation.

- Functional enhancement for related database
The Data and Sample Research System for Whole Cruise Information (DARWIN) disseminates information of research cruise, dive, observation data and samples obtained by JAMSTEC's research vessels and submersibles. DARWIN has been enhanced to allow linkage of DOI metadata with the Data DOI Management System via Web API to achieve effective DOI maintenance for a large amount of content.

- Survey of DOI for research data
A wide variety of databases depending on the disciplines, research project, and types of data are disseminated by several departments and groups within JAMSTEC. Therefore, a survey of minting DOI for research data is being conducted to grasp data creators' needs. We extracted the target databases from catalog metadata published in JAMSTEC data catalog. The questions in this survey ask about ownership of data, conditions for data usage, granularity of DOI assignment, and continuity of database services.

The first edition of guidelines for minting DOIs for research data in JAMSTEC will be developed based on the practical operation of systems and the survey results by the end of the year 2019.

Related URLs
JAMSTEC Data DOI, http://www.jamstec.go.jp/datadoi/doi/10.17596/e/about.html
DARWIN, http://www.godac.jamstec.go.jp/darwin/e
JAMSTEC data catalog, http://www.godac.jamstec.go.jp/catalog/data_catalog/e/

Keywords: open science, open research data, DOI

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Application of Web and GIS Technology to Develop Military's Differential Action Information Platform

*Chien Hao Chang[1], Ch Yu Liu[1], Chun Ta Wei[1]

1. Department of Computer Science and Information Engineering,CCIT

Taiwan is located in a special environment where geographical location and plate transfer, rainfall and earthquakes occur frequently, geological disasters are diverse and complex, and disaster prevention is an important issue that cannot be evaded by the whole people. In the face of such frequent natural disasters, the government’ s disaster prevention and relief work is particularly important.
On July 13, 1999, the Legislative Yuan officially read the "Disaster Prevention Act" [1] sub-amendment amendment, which not only allowed the Fire Department to transform into a disaster prevention and rescue department, but also assigned the national army to prevent disasters. Source of law. In keeping with the "disaster relief as a warfare" attitude, the National Army can, in response to each exercise and drill, be able to give full play to the rapid relief efforts of the national army in the golden rescue moment of major disasters, and avoid the national social disaster caused by environmental safety issues. The National Army has followed the policy guidance of "advance deployment, pre-set strength, and always-time rescue" for disaster relief, and is on standby to carry out disaster prevention and rescue missions such as preventive evacuation to protect the lives and property of the people.
To construct a multi-disaster information platform from the forward-looking command post to the users of the various levels of command posts at the back-end, to provide real-time information on the disaster relief center, to facilitate the disaster, and to control and issue orders through the information platform. For the officers and men, the mission is smooth and the delivery time is shortened. After the National Army has been refined, the number of people has been greatly reduced. In the future, in the implementation of disaster prevention, it is necessary to integrate and properly use the resources of the entire army to meet the needs of the people.

Keywords: disaster relief, military, information platform

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[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | A04 TOKYO BAY MAKUHARI HALL

[M-GI31] Open Science in Action: Research Data Sharing, Infrastructure, Transparency, and International Cooperation

convener:Yasuhiro Murayama(Strategic Program Produce Office, National Institute of Information and Communications Technology), Yasuhisa Kondo(Research Institute for Humanity and Nature), Shelley Stall(American Geophysical Union), Baptiste Cecconi(LESIA, Observatoire de Paris, CNRS, PSL Research University), Chairperson:Baptiste Cecconi(LESIA - Observatoire de Paris)

Open Science is growing up as a new research paradigm to accelerate scientific innovation. Deployed by ICSU-WDS (2008), G8 Open Data Charter (2013), deployment of Research Data Alliance (2013), OECD Global Science Forum's research projects (2016), and G7 Science Ministers' Communique (2017), it commonly refers to the top-down policies to make results of publicly-funded research freely available and accessible. On the other hand, this term also refers to the participatory bottom-up approaches such as citizen science, crowdfunding, and transdisciplinary research (Kitamoto 2016). It is noted that both approaches envision the transformation of research process to more findable, accessible, interoperable, and reusable one (Wilkinson et al. 2016).
After the JpGU-AGU Great Debate "Role of open data and open science in Geoscience" in JpGU Annual Meeting 2018 and a follow-up session in the AGU Fall Meeting 2018, this session reviews the current broad spectrum of Open Science in an international context. The session welcomes a wide range of papers and posters covering (but not limited to) open research data, open source licenses, data papers and journals, data repository, data sharing infrastructures and platforms, citizen science, crowdsourcing, crowdfunding, transdisciplinary research, capacity building, international networking, and deployment in earth and planetary sciences.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MGI31-13] Adoption of IGSN in the International Ocean Discovery Program (IODP)

*Sean Toczko[1] (1.Japan Agency for Marine-Earth Science and Technology)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MGI31-14] Oceanogrpahic Data and Information Exchange for Open Science

*Toru Suzuki[1] (1.Marine Information Research Center)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI31-15] The International Heliophysics Data Environment Alliance (IHDEA) initiative
★Invited Papers

*Arnaud Masson[1], Aaron Roberts[2], Shing Fung[2], Bob McGuire[2], Jack Ireland[2], Jeremy Faden[12], Jim Lewis[9], Baptiste Cecconi[7], Vincent Genot[8], J.C. Malapert[4], Keiichi Matsuzaki[3], Todd King[5], Daniel Mueller[6], Jon Vandegriff[10], Miyoshi Yoshizumi[11] (1.ESAC Science Data Center, European Space Agency, Madrid, Spain, 2.NASA/GSFC, USA, 3.JAXA, ISAS, Tokyo, 4.CNES, Toulouse, 5.UCLA, USA, 6.ESTEC, European Space Agency, Noordwijk, The Netherlands, 7.LESIA, Observatoire de Paris, France, 8.IRAP, CNRS, Toulouse, 9.Berkeley University, USA, 10.John Hopkins, APL, USA, 11.ISEE, Nagoya University, Nagoya 464-8601, Japan, 12.Cottage Systems, University of Iowa, USA)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI31-16] **VESPA: Progress on the Planetary Science Virtual Observatory**

*Stephane Erard[1] (1.Observatoire de Paris / LESIA)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI31-17] Publishing planetary science data following FAIR principles

*pierre le sidaner[1], Baptiste Cecconi[2], Stephane Erard[2], Cyril Chauvin[1], Albert Shih[1], Stephane Aicardi[1], Philippe Hamy[1], Alan Loh[2] (1.DIO - Observatoire de Paris, Universite PSL, CNRS UMS2201, 2.LESIA,

Observatoire de Paris, Universite PSL, CNRS, Sorbonne Université, Univ. Paris Diderot, Sorbonne Paris Cite)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI31-18] Community-developed open tools for supporting the ESA JUICE space mission preparation

*Baptiste Cecconi[1], Alan Loh[1], Stephane Aicardi[2], Corentin Louis[3] (1.LESIA, Observatoire de Paris, CNRS, PSL Research University, Meudon, France, 2.DIO, Observatoire de Paris, CNRS, PSL Research University, Paris, France, 3.IRAP, CNRS-Université Paul Sabatier, Toulouse, France)

Adoption of IGSN in the International Ocean Discovery Program (IODP)

*Sean Toczko[1]

1. Japan Agency for Marine-Earth Science and Technology

The International Ocean Discovery Program (IODP) has moved to adopt the International Geo Sample Number (IGSN). This describes some of the details in adpoting this system to an existing subseafloor core sample respository at the Kochi Core Center (KCC), JAMSTEC.

Keywords: IODP, IGSN, KCC, JAMSTEC

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Oceanogrpahic Data and Information Exchange for Open Science

*Toru Suzuki[1]

1. Marine Information Research Center

For more than 50 years, the International Oceanographic Data and Information Exchange (IODE) of the Intergovernmental Oceanographic Commission (IOC) of UNESCO has promoted and facilitated the exchange of oceanographic data and information between Member States for development and enhancement of marine research. The IODE system consists of 80 and more National Oceanographic Data Centres (NODC), Associated Data Units (ADU; former Designated National Agencies (DNAs)), and those data centres have been responsible for the collection, management, quality control and archive oceanographic data observed in each Member States. The World Ocean Database (WOD), gathering oceanographic data through IODE system, is most useable data product by National Centers for Environmental Information (former US-NODC), NOAA, and is also one of achievements by IODE projects for WOD and Global Oceanographic Data Archeology and Rescue (GODAR). Japan Oceanographic Data Center (JODC) is a representative of Japan for IODE and is the second largest contributor to WOD. The Ocean Biogeographic Information System (OBIS) joined as one of IODE projects in June 2009 after the successful decade-long Census of Marine Life project. The IODE system have many other projects for oceanographic data and information collection, quality control and dissemination managed by steering groups or task teams, and has a role of technical support to the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) by World Meteorological Organization (WMO) and IOC. The IODE joined as one of network members of World Data Systems (WDS) in 2013. At the same time IODE has started the Quality Management Framework project to identify a set of quality management criteria for NODCs taking into account those defined for the WDS, and JODC received NODC accreditation in 2019. In 2003 the IOC Assembly adopted Resolution IOC-XXII-6 entitled “IOC Oceanographic Data Exchange Policy” which is mentioned about the timely, free and unrestricted access to all oceanographic data and associated metadata and products. It is nevertheless known that there are many non-disclosure or non-digitized historical data and needs to progress a data publication and citation system for evaluating data management works.

Keywords: Oceanographic data, Data and information exchange, Quality control

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The International Heliophysics Data Environment Alliance (IHDEA) initiative

*Arnaud Masson[1], Aaron Roberts[2], Shing Fung[2], Bob McGuire[2], Jack Ireland[2], Jeremy Faden[12], Jim Lewis[9], Baptiste Cecconi[7], Vincent Genot[8], J.C. Malapert[4], Keiichi Matsuzaki[3], Todd King[5], Daniel Mueller[6], Jon Vandegriff[10], Miyoshi Yoshizumi[11]

1. ESAC Science Data Center, European Space Agency, Madrid, Spain, 2. NASA/GSFC, USA, 3. JAXA, ISAS, Tokyo, 4. CNES, Toulouse, 5. UCLA, USA, 6. ESTEC, European Space Agency, Noordwijk, The Netherlands, 7. LESIA, Observatoire de Paris, France, 8. IRAP, CNRS, Toulouse, 9. Berkeley University, USA, 10. John Hopkins, APL, USA, 11. ISEE, Nagoya University, Nagoya 464-8601, Japan, 12. Cottage Systems, University of Iowa, USA

The IHDEA was formed as a result of the first International Heliophysics Data Environment (IHDE) meeting held at the European Space and Astronomy Centre (ESAC), Madrid, Spain, on October 17-18, 2018. Meeting attendees representing NASA, ESA, JAXA, and CNES have all agreed that increasing collaboration and coordination through the use of standard formats (for both data and metadata) and community-based data tools are critical for enabling interoperability of data systems and services and improving sharing of space-based, ground-based, and model-based heliophysics data sets.

The newly created International Heliophysics Data Environment Alliance (IHDEA) is a collaborative organization whose goal is to guide the development of a data environment in which the international heliophysics and space weather research community can seamlessly find, access, and use all electronically accessible, heliophysics relevant data sets.

The specific mission of the IHDEA is to facilitate global access to, and exchange of, high quality scientific data products managed across international boundaries. This will be achieved by adhering to, and promote the use of, a set of governing data standards, data exchange protocols, visualization and data analysis tools.

The role of the IHDEA is to serve as the focal point to engage the heliophysics data centres and the scientific community, foster communication, and identify and identify the standards and services that will best serve the heliophysics and space weather science needs.

Practical examples will be provided, illustrating the mutual interest to foster collaboration between key heliophysics data providers.

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VESPA: Progress on the Planetary Science Virtual Observatory

*Stephane Erard[1]

1. Observatoire de Paris / LESIA

The Europlanet-2020 programme, started Sept 1st, 2015 for 4 years, includes an activity called VESPA which focuses on adapting Virtual Observatory (VO) techniques to handle Planetary Science data. The main objectives of VESPA are to facilitate searches both in big archives and in small databases, to enable data analysis by providing simple data access and on-line visualization functions, and to allow research teams to publish derived data in an interoperable environment as easily as possible. VESPA encompasses a wide scope, including surfaces, atmospheres, magnetospheres and planetary plasmas, small bodies, heliophysics, exoplanets, and spectroscopy in solid phase. This system relies in particular on standards and tools developed for the Astronomy VO (IVOA) and extends them where required to handle specificities of Solar System studies. It also aims at making the VO compatible with tools and protocols developed in different contexts, for instance GIS for planetary surfaces, or time series tools for plasma-related measurements. An essential part of the activity is to publish a significant amount of high-quality data in this system, with a focus on derived products resulting from data analysis or simulations

[1] Erard et al 2014, *Astronomy & Computing* **7-8**, 71-80. http://arxiv.org/abs/1407.4886

Keywords: Solar System, Virtual Observatory , GIS

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Publishing planetary science data following FAIR principles

*pierre le sidaner[1], Baptiste Cecconi[2], Stephane Erard[2], Cyril Chauvin[1], Albert Shih[1], Stephane Aicardi[1], Philippe Hamy[1], Alan Loh[2]

1. DIO - Observatoire de Paris, Universite PSL, CNRS UMS2201, 2. LESIA, Observatoire de Paris, Universite PSL, CNRS, Sorbonne Université, Univ. Paris Diderot, Sorbonne Paris Cite

On the frame of Europlanet-2020-RI VESPA program we have developed an infrastructure to publish Solar System data. Our pipeline and tools follow the Open Data and FAIR (Findable Accessible Interoperable Reusable) principles. It uses protocols and infrastructures developed and maintained by the IVOA (International Virtual Observatory Alliance). It takes advantage of 15 years of experience in astronomical data sharing with interoperable data centers distributed all over the world. VESPA follows the IVOA models that define an interoperable system to describe, discover and search data collections and services. It uses standard data access protocols, formats and metadata descriptions. The specificity of the IVOA model is to propose a distributed system. The data are stored at each provider data center with interoperable layers on top of them. This model allows exponential increasing in data volume. One the next largest current project, SKA (Square Kilometer Array) is planning to produce more data than Google, Facebook and Youtube together. IVOA models will have to face this. VESPA proposes an extension to IVOA protocoles for handling Solar System data, namely: a data model for Solar System data product metadata. I will present TAP (Table Access Protocol) as a toolkit to publish a large type of data. This protocol can be associated to a data model to publish planetary data (surface, atmosphere), plasma physics, solar physics, spectroscopic property, time series, exoplanetary dataset, etc. I will also describe how the VESPA project makes use of it to publish any type of planetary science data.

VESPA is part of the Europlanet H2020 Research Infrastructure project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654208

Keywords: interoperability, virtual observatory, FAIR, Planetary science data

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Community-developed open tools for supporting the ESA JUICE space mission preparation

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1. LESIA, Observatoire de Paris, CNRS, PSL Research University, Meudon, France, 2. DIO, Observatoire de Paris, CNRS, PSL Research University, Paris, France, 3. IRAP, CNRS-Université Paul Sabatier, Toulouse, France

The MASER (Measurements, Analysis and Simulation of Emissions in the Radio range) and VESPA (Virtual European Solar and Planetary Access) teams are proposing a set of tools and dataset used for preparing the ESA-lead JUICE (Jupiter Icy moon Explorer) space mission, with a focus on magnetospheric science topics. The case of the observation planning and science mode assessment in the frame of the JUICE mission is described. This case shows how Jovian radio emissions observations and simulations are used by the JUICE science and operation teams. Developments using the EOSC (European Open Science Cloud) infrastructure are also envisaged in the near future.

Keywords: Radio astronomy, Space mission, Jupiter

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_27

[M-GI32] Collaboration and Co-creation of Geoscience, Art and Design

convener:kubo takashi(MAIBUNKAN), Noriko SHIRAISHI(Department of Earth and Planetary Craft)

The big theme of this session is "Collaboration and Co-creation between science and expression". In this theme, we discuss several advantages in using an artistic technique for research outcome of geoscience, collaborated artworks between geoscience and art, and new fields of geoscience expected in the future that result from using artistic expression in expressing geoscience. This is the real situation surrounding our academic world of geoscience that there is little chance for a geoscientist to learn artistic expression and technique in a professional way.
In this session, specialists of art and design talk and introduce "the tool of expression" that help us when geoscientists give a research talk fascinatingly in order to get the research funding or to advocate one's own theory. Furthermore, we provide a unique panel discussion about geoscience in the next-generation that is expected to come into the academic world of geoscience by geoscientist absorbing artistic technique.

[MGI32-P01] Photography in geomorphology

*Yuichi S. Hayakawa[1] (1.Faculty of Environmental Earth Science, Hokkaido University)

[MGI32-P02] Co-create Expression of the Earth Science with an Art museum and artist and Natural history museum.

*kubo takashi[1], chikako syakudo[2] (1.MAIBUNKAN, 2.Kurobe City Art Museum)

Photography in geomorphology

*Yuichi S. Hayakawa[1]

1. Faculty of Environmental Earth Science, Hokkaido University

Geomorphology is a study of landforms and the photographs of landscapes are generally regarded as an essential component of geomorphological studies. The author introduces some of its photographic works of landscape capturing with academic descriptions, which are also potentially effective in the dissemination of geomorphological knowledge and thinking to the public. The technique of photography required for the geomorphological purposes are not necessarily to be much advanced, but both basic and advantageous photographic skills are recommended to have for geomorphologists because the presentations will become richer if they have advanced skills. The author also seeks the opportunities to link the professional photographers and geomorphologists to have a better understanding of landform developments for general people.

Keywords: photography, landscape, geomorphological process

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Co-create Expression of the Earth Science with an Art museum and artist and Natural history museum.

*kubo takashi[1], chikako syakudo[2]

1. MAIBUNKAN, 2. Kurobe City Art Museum

Earth science continually impacts people’s view of the universe and life, through facts discovered in the course of its advance, and generates concepts essential to understanding the natural world and pursuing daily life in society. On the other hand, art is a creative endeavor, based on abstract concepts that have been ongoing since the dawn of humanity, and it continues to contribute to the spiritual development of humanity. Scientific discoveries have sometimes become inspirational materials for works of art, helping to broaden people’s outlook. Since 2016, Kurobe City Art Museum and Asahi Town Center For Archaeological Operations (“Maibun KAN”), have collaborated with artists to create works of art inspired by archaeology and earth science in the local community, and to hold exhibitions and events. In 2018, modern artist Tatsuo Kawaguchi was invited to observe nature outdoors together with curators, which resulted in works of art inspired by fossils, rocks, and earth science concepts. These artworks and related specimens have been exhibited at Kurobe City Art Museum and Maibun KAN. In this project, the artist conducted earth science observations outdoors, and people acknowledged the interaction between art and earth science through artworks arising from the artist’s sensibilities and expressive capabilities. As a result of this project, types of people who normally visit exclusively the Art Museum or Maibun KAN also visited the other facility. At the presentation venue, we will exhibit catalogs from Kurobe City Art Museum, and Lower Jurassic sedimentary blocks, containing invertebrate fossils, from the Kuruma Group, which served as inspirational materials for artworks.

Keywords: Art&Science

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_44

[M-GI32] Collaboration and Co-creation of Geoscience, Art and Design

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*Yuichi S. Hayakawa[1] (1.Faculty of Environmental Earth Science, Hokkaido University)

[MGI32-P02] Co-create Expression of the Earth Science with an Art museum and artist and Natural history museum.

*kubo takashi[1], chikako syakudo[2] (1.MAIBUNKAN, 2.Kurobe City Art Museum)

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Keywords: photography, landscape, geomorphological process

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*kubo takashi[1], chikako syakudo[2]

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Keywords: Art&Science

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_10

[M-GI37] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University)

Increasingly large and complex data are produced by observations and numerical simulations in earth and planetary sciences. The target of this session is to discuss a broad range of practices and new knowledge of informatics, international standard and modelling, including techniques for large-scale data processing and numerical simulation, data preservation and publication, data transfer and collection and other data technologies with a vision to advance an emerging data-intensive science, namely "geoplanetary informatics".

[MGI37-P01] Publication of georeferenced polygon data to make JMA XML machine-readable

*Eizi TOYODA[1] (1.Administration Department, Japan Meteorological Agency)

[MGI37-P02] Development of a web system for search, browsing and download of Akatsuki's observation data

*Ko-ichiro SUGIYAMA[1], Kosei Murakoso[1], Kazuki Oomori[1,3], Takumi Aoki[1,4], Shin-ya Murakami[2] (1.National Institute of Technology, Matsue College, 2.ISAS/JAXA, 3.NTT DATA MHI Systems Corporation, 4.Mazda E&T)

[MGI37-P03] Large amount of data related to D/V Chikyu and science support activities

*Yukari Kido[1], Takamitsu Sugihara[1], Yoshinori Sanada[1], Tatsuya Murayama[1] (1.Japan Agency for Marine-Earth Science and Technology)

[MGI37-P04] Data delivery and visualization service for climate forecast data in the Arctic Ocean during R/V Mirai cruise MR18-05

*Takeshi Terui[1], Takeshi Sugimura[1], Liyanarachchi Waruna Arampath De Silva[2], Souichiro Sueyoshi[3], Jun Inoue[1] (1.National Institute of Polar Research, 2.The University of Tokyo, 3.Nippon Marine Enterprises)

[MGI37-P05] Improvement of mineral mapping accuracy by increasing spectral band and spatial resolutions of multispectral optical sensor imagery

*Katsuaki Koike[1], Nguyen Tien Hoang[1], Shuho Noda[2], Yukie Asano[2], Yuu Kawakami[2], Kazuo Masuda[2] (1.Laboratory of Environmental Geosphere Engineering, Department of Urban Management, Graduate School of Engineering, Kyoto University, 2.Japan Oil, Gas and Metals National Corporation (JOGMEC))

[MGI37-P06] Analysis of vessel status information of past research cruises and prediction of downtime for future cruise

*Yasuko Yamagishi[1], Ken Yatsu[2], Kazuhiko Kashiwase[2], Tetsuji Maki[2], Yuta Yamamuro[2,3], Hide Sakaguchi[1] (1.MAT, JAMSTEC, 2.MARITEC, JAMSTEC, 3.Nippon Marine Enterprises, Ltd.)

[MGI37-P07] Verification of an ocean monitoring system using a climate satellite "Himawari"

*YUUICHI KAGA[1], SHIGETO WATANABE[1] (1.Hokkaido Information University)

[MGI37-P08] Development of smooth area detection method for selection of landing site on a small body

Yuki Fujii[1], *Rie Honda[1], Tomokatsu Morota[4], yokota yasuhiro[2], ERI TATSUMI[3], Naoya Sakatani[2], Manabu Yamada[9], Shingo Kameda[5], Toru Kouyama[10], Hidehiko Suzuki[6], Chikatoshi Honda[7], Masahiko

Hayakawa[2], Kazuo Yoshioka[3], Yuichiro Cho[3], Yukio Yamamoto[2], Naru Hirata[7], Naoyuki Hirata[8], Hirotaka Sawada[2], Seiji Sugita[3] (1.Kochi University, 2.ISAS/JAXA, 3.University of Tokyo, 4.Nagoya University, 5.Rikkyo University, 6.Meiji University, 7.Aizu University, 8.Kobe University, 9.Chiba Institute of Technology, 10.National Institute of Advanced Industrial Science and Technology)

[MGI37-P09] Activity Report of Hackathon Event "SpaceHack 2019" for Utilization of Space Data

*Tsubasa Yumura[1], Satoshi Kikuchi[1], Tsutomu Nagatsuma[1], Ken T. Murata[1] (1.National Institute of Information and Communications Technology)

[MGI37-P10] Experimental Evaluation of High-Speed File Transfer over JHPCN

*Praphan Pavarangkoon[1], Ken T. Murata[1], Kazunori Yamamoto[1], Takamichi Mizuhara[2], Yuya Kagebayashi[2], Ayahiro Takaki[2], Kazuya Muranaga[3], Keiichiro Fukazawa[4] (1.National Institute of Information and Communications Technology, Tokyo, Japan, 2.CLEALINK TECHNOLOGY Co., Ltd., Kyoto, Japan, 3.Systems Engineering Consultants Co., Ltd., Tokyo, Japan, 4.Academic Center for Computing and Media Studies, Kyoto University, Kyoto, Japan)

[MGI37-P11] Programming Environment of Visual IoT Tools Working on Single-Board Computer (Raspberry Pi) (2)

*Takamichi Mizuhara[1], Ken T. Murata[2], Praphan Pavarangkoon[2], Somnuk Phon-Amnuaisuk[3], Kazunori Yamamoto[2], Kazuya Muranaga[4], Toshiki Aoki[1] (1.CLEALINK TECHNOLOGY CO., LTD., 2.National Institute of Information and Communications Technology, 3.Universiti Teknologi Brunei, 4.Systems Engineering Consultants Co., LTD.)

[MGI37-P12] Real-Time Monitoring Technique of Earth Environment via Visual IoT

*Kazunori Yamamoto[1], Ken T. Murata[1], Takamichi Mizuhara[2], Praphan Pavarangkoon[1], Kazuya Muranaga[3], Toshiki Aoki[2] (1.National Institute of Information and Communications Technology, 2.CLEALINK TECHNOLOGY Co., Ltd., 3.Systems Engineering Consultants Co.,LTD.)

[MGI37-P13] International Deployment of real-time web of Himawari (meteorological satellite) data: A case of mirroring to Philippines

Kazuya Muranaga[1], Praphan Pavarangkoon[2], Kazunori Yamamoto[2], *Ken T. Murata[2], Atsushi Higuchi[3] (1.Systems Engineering Consultants Co., LTD., 2.National Institute of Information and Communications Technology, 3.Chiba University)

[MGI37-P14] Visualization of Himawari-8 observation data using high resolution animation: The case studies of CEReS, Chiba University, Japan

*Koichi Toyoshima[1], Atsushi Higuchi[1] (1.Center for Environmental Remote Sensing, Chiba University)

[MGI37-P15] Performance evaluation of inter-node MPI parallel TensorFlow for massive learning data

*Keiichiro Fukazawa[1] (1.Academic Center for Computing and Media Studies, Kyoto University)

Publication of georeferenced polygon data to make JMA XML machine-readable

*Eizi TOYODA[1]

1. Administration Department, Japan Meteorological Agency

Japan Meteorological Agency (JMA) has developed an XML format to structurized replacement for traditional plain text bulletins in Japanese text (Kana-Kanji messages) used for alerting messages such as warnings and advisories. The JMA's XML format reduced ad-hoc parsing work of plain text, while the geolocation remained as issue. Messages issued for fixed geographical areas (like prefectures or municipalities) contain only code for the areas, and users had to prepare polygon data by the area's name for visualization.
January 2019, JMA published georeferenced polygon data (in shapefiles). Challenges will be presented during the session, including the selection of horizontal resolution and the clarification of geographical areas. JMA expects the polygon data expands the utilization of JMA's XML messages in other formats or in conjunction with other geospatial information.

Keywords: JMA XML, geospatial polygon data, open data

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Development of a web system for search, browsing and download of Akatsuki's observation data

*Ko-ichiro SUGIYAMA[1], Kosei Murakoso[1], Kazuki Oomori[1,3], Takumi Aoki[1,4], Shin-ya Murakami[2]

1. National Institute of Technology, Matsue College, 2. ISAS/JAXA, 3. NTT DATA MHI Systems Corporation, 4. Mazda E&T

Venus climate orbiter "Akatsuki" observes clouds of different altitudes using five cameras with narrowband filters at different wavelengths. The images taken by Akatsuki are published on NASA's Planetary Data System (PDS) [1] and AKATSUKI Science Data Archive [2] of ISAS/JAXA's Data ARchives and Transmission System (DARTS) [3] after a certain period of time has elapsed. However, because the images taken by each camera are archived in different directories on the websites, there is a problem that it is difficult to get an overview of data obtained by cooperatively observing with multiple wavelengths.

With this background in mind, we have been developed a web system named "Akatsuki Data Search" [4] using Ruby on Rails. Our system provides easy search, browsing and download of data published on the above sites. In order to investigate the three-dimensional motion of Venus atmosphere over time that is the purpose of the Akatsuki project, we implement a function to generate the image list page using observation program names and its execution times described in header of the data files. This function makes it possible to compare cloud images at different altitudes taken at the same time and to display time variation of cloud distribution at the same altitude. Furthermore, in order to response the request to search data by information not written in header of the data files (e.g. images used for an article), function of "my favorite" is implemented. This function makes it possible to save the names of favorite data files or search condition used to obtain the files and to share the favorites with users.

In our presentation, we will explain and demonstrate our system in detail.

References:

[1] The Planetary Data System (PDS), https://pds.nasa.gov

[2] AKATSUKI Science Data Archive, https://www.darts.isas.jaxa.jp/planet/project/akatsuki/

[3] Data ARchives and Transmission System (DARTS), https://www.darts.isas.jaxa.jp/

[4] Akatsuki Data Search, https://vco.epi.it.matsue-ct.jp/

Keywords: Venus climate orbiter "Akatsuki", Web System, big data

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Large amount of data related to D/V Chikyu and science support activities

*Yukari Kido[1], Takamitsu Sugihara[1], Yoshinori Sanada[1], Tatsuya Murayama[1]

1. Japan Agency for Marine-Earth Science and Technology

It has been 14 years passed since deep drilling vessel "Chikyu" delivered to Japan Agency of Marine-Science and Technology Center (here after JAMSTEC) in July, 2005. D/V Chikyu is one of main drilling platforms in the frame work of International Drilling program which was cerebrated the just 50th anniversary by 2018. During the period, getting improvements of drilling technology, Chikyu performed remodel and reform aging laboratory equipment and a scientific support activity. Her drilling records are “16” expeditions, the number of days of more than 1000 days, 350 participants from 27 countries in scientific drilling project, 41 km drilling lengths, deepest water depth of 6,928.5 m (Exp.343), 101 drilling holes, 5.6 km cumulative collected core lengths, 1060 cores and more than 3,262.5 m of deepest hole records (Exp.358) since Exp.314 the first mission of IODP (as of February 2019). We are doing scientific services modeled after D/V Joides Resolution led by USA and investigating a questionnaire and request to the laboratory performed at the time of a sailing end of each time. Data management, a QC system and data delivery service to a researcher are being performed so that the quality of the data service may be also kept in a constant and to some amount of level. There are widely and many aspects of scientific support activities as carrying site survey, documentation and preparation for audit of scientific drilling, planning of stratigraphic inspection and data quality check. Wide range of activity as well as witness of operation, data process, delivery and report making support are carried out. Onboard scientific drilling workshop putting on the past data acquired so far at the same area, and new proposal system of Chikyu Shallow piston Core Program (SCORE) are running. Chikyu provides a realistic environment for researchers to concentrate on and throw themselves into research activities. A various categorized core schools for the next generation and other research field participants are also supporting. Logging schools are long running beyond 10 years and collaborating with Asian countries. The support activity with the enormous volume of data, the researcher and the engineer who surround "Chikyu" from the view point of scientific support are discussed and promoted deepened and more profoundly.

Keywords: Drilling Vessel Chikyu, IODP, Science Drilling Support

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Data delivery and visualization service for climate forecast data in the Arctic Ocean during R/V Mirai cruise MR18-05

*Takeshi Terui[1], Takeshi Sugimura[1], Liyanarachchi Waruna Arampath De Silva[2], Souichiro Sueyoshi[3], Jun Inoue[1]

1. National Institute of Polar Research, 2. The University of Tokyo, 3. Nippon Marine Enterprises

Understanding of the weather situation is the most important issue for observation cruse in the sea ice area. In particular, overviewed information of 1000 km scale is a good indication to determine a safe route and plan, and the weather forecast and observation data is required. However, limited satellite telecommunication line on the ship makes on-demand data delivery difficult. And more, if the compressed data would be sent via this line, a professional staff for decoding and visualizing the data must always be needed on the ship. In order to reduce these anxiety and burden, automatically system integrating these processes (delivery, decoding, and visualizing data) is needed. ADS (Arctic Data archive System) has been developed the new integrated system for the ship to delivery and visualize data, which is called VENUS (VEssele Navigator by Unitized Systems). This system has been implemented to R/V Mirai cruise in the Arctic Ocean since MR16-06. MR18-05 cruse was a winter observation in the Arctic Ocean, and we delivered 10 days weather forecast data produced byECMWF, and high resolution sea ice forecast model output from IcePOM developed in the University of Tokyo. Total size of delivered data via e-mail was reached to about 100 MB/day, and more than 100 e-mails were delivered to Mirai every day. Our system was always in a high load condition due to visualization processing. We need to In this research, we want to introduce technical performances and advantages of this system. For safe cruse, we must complete the transmission and visualization of such massive data by the scheduled time. Therefore, we devised a lot of solutions to solve the technical difficulties. In this research, we introduce what we did to solve these problems and discuss various issues of data distribution and processing in ship.

Keywords: Arctic Ocean, Ship Observation, IoT, Forecast Data, Visualization, Satellite communication

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Improvement of mineral mapping accuracy by increasing spectral band and spatial resolutions of multispectral optical sensor imagery

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Multispectral optical sensor images widely used in geologic remote sensing have covered all Earth land areas for a long time and vast data have been accumulated. However, their numbers of spectral bands are few (usually around ten) and spatial resolutions are relatively low, which decreases discrimination accuracy of mineral and rock types. Observation areas by hyperspectral imagery and high-resolution imagery are limited locally and costly. For this problem, this study aims to develop two transformation methods of general multispectral satellite imagery all over the scene into (1) hyperspectral imagery with many bands and (2) high spatial resolution imagery equivalent to the highest resolution level in the present geologic remote sensing, towards finally a simulation of hyperspectral, hyperresolution imagery for advanced exploration of metal and geothermal resources and precise monitoring of geologic environments. In this study, ASTER, AVIRIS, and WorldView-3 (WV-3) images were selected as representative multispectral (MS), hyperspectral (HP), and high spatial resolution (HSR) imagers, respectively. The spatial resolutions in the short-wave infrared region (SWIR), essential to discrimination of minerals, are ASTER: 30 m and WV-3: 7.5 m.

As for the first hyperspectral transformation, we use PHITA developed by the authors (Pseudo-Hyperspectral Image Transformation Algorithm: Hoang and Koike, 2017; 2018). This method is based on multiple regression model for correlations between MS and HP band reflectance data, and selects the best model through Bayesian model averaging. One pixel of MS image consists of several pixels of overlapped HP image (e.g., one pixel of ASTER = 4×4 pixels of WV-3 image). As for the second hyperresolution transformation, an assumption that a radiance at one pixel of MS image is summation of radiances at several, corresponding pixels of HSR image is set, and their relationship is quantified by a generalized additive model (Stasinopoulos et al., 2018) that is more versatile and rigorous than traditional multiple regression model.

A part of the Cuprite hydrothermal alteration area in the western United States for which ASTER, WV-3, and AVIRIS images were available was selected as training area for the two methods, and a principle of machine learning was adopted for the targeted Goldfield near Cuprite, a world-famous epithermal deposit area. An ASTER image in Cuprite was transformed into a pseudo-AVIRIS image by PHITA and their regression model was applied to an ASTER image of Goldfield. As the result, detection accuracies of hydrothermal alteration minerals such as alunite and kaolinite were largely increased. Four SWIR bands whose wavelengths were common between ASTER and WV-3 were used for the hyperresolution. By applying a correlation rule between the ASTER and WV-3 images obtained for Cuprite to Goldfield, the ASTER image of Goldfield was downscaled to the WV-3 resolution and consequently, mapping of minerals such as alunite was achieved more in detailed than the ASTER resolution. These two outcomes were verified by a ground-truth survey in 2018 and an XRD analysis of the samples by it, which demonstrates correctness and effectiveness of the proposed hyperspectral and hyperresolution methods.

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Keywords: Hyperspectral imagery, Hydrothermal alteration mineral, Multiple regression model, Short-wave infrared region, Cuprite, Goldfield

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Analysis of vessel status information of past research cruises and prediction of downtime for future cruise

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Japan Agency for Marine-Earth Science and Technology (JAMSTEC) owns several research vessels and is responsible for the operation of the research cruise by these vessels. The ship time of research vessels belonging to JAMSTEC has declined over the last 10 years due to decrease in the number of vessels and the budget for research cruises. On the other hand, the occurrence of trench type large earthquake, global warming, and seabed resource exploration have increased the importance of the oceanic observation. Under these circumstances, it is indispensable to plan the most optimal research cruises to carry out the necessary oceanic observations. At present, JAMSTEC has to plan all research cruises for next fiscal year one year before. In order to perform the most effective research cruises, our project aims to provide useful information when planning future research cruise. Our project started in FY 2016. We first started to investigate the efficiency of the past research cruises. We have compiled time-sequence data of vessel status and performed observations in the past cruise, and estimated downtime for each cruise, which is a period when the observation or cruise is interrupted due to rough weather, machine trouble, etc. The downtime is one of the indicators for the efficiency of the research cruise. We also have developed database system to store the time-sequence data and information of each research cruises including downtime. The time-sequence data has been compiled based on E-mail sent from vessel to ground management office in the cruise. In E-mail, the information is written in text, ie in natural language. Therefore, the time-sequence data should be compiled by manually, it takes a lot of time to digitize it. Currently, we are also developing an application that automatically create the time-sequence data of vessel status and performed observation. Next, we have analyzed the downtime and the information of the past research cruises and searched for important factors that affect the downtime. And then, we have developed an application to predict the downtime of future cruises by using machine learning. In this study, we will introduce the analysis results of the downtime and the progress of the application development. Acknowledgments: we are grateful to Mr. Morisaki and Ms. Sada for their supports to make data stored into the database system.

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Verification of an ocean monitoring system using a climate satellite "Himawari"

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We have developed an application of ocean condition monitoring system with iPad and/or iPhone. The application can obtain the sea conditions and the catch amounts around Japan. We present some results of relation between the sea conditions and the catch amounts under the collaborations with fishermen in this presentation.

Keywords: meteorological satellite "Himawari", ocean monitoring, big data

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Development of smooth area detection method for selection of landing site on a small body

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Hayabusa2 arrived at asteroid Ryugu on June 2018 and scheduled to conduct touch-down to its surface. We have developed a smooth area detection method for selecting smooth area for landing on a small body such as an asteroid. The small dark or bright spot of 1 pixel scale which might be an boulder, or some obstacles are detected by subtracting the smoothed images via median filter from the raw images. Then the coverage of these possible boulder or obstacle pixels are calculated for a circular area which represents the footprint of the accuracy of the landing, and the area with the less coverage is selected as the safer area for landing. Furthermore, the method based on the clustering of texture of the small block area. Application to Ryugu Images obtained by Hayabusa2 ONC-T will be introduced in the presentation.

Keywords: automatic detection, smooth area, clustering, median filter

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Activity Report of Hackathon Event "SpaceHack 2019" for Utilization of Space Data

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National Institute of Information and Communications Technology (NICT) accumulates various observation data about space in each research group. Some of these data are disclosed on the website. In order to promote the utilization of this data, we have planned the Hackaston event "SpaceHack 2019”. Hackathon is a collective term for events that creates systems and applications in a short period of about a few days, and is held numerous by voluntary organizations, companies, local governments, and so forth. SpaceHack 2019 recruited general participants outside NICT and held for two days. On the first day, after explaining the event overview and explaining the available data, we implement ideason to brush up ideas among participants. Based on the results of Ideason, articipants form a team develop until the afternoon on the second day. After the development, presentation, review, and recognition are carried out. SpaceHack provides participants with cloud system for scientific research “Science Cloud”, high speed R&D network testbed “JGN” and large scale emulation testbed “StarBED”. In our presentation, we will report the summary of SpaceHack 2019 and discuss the possibility of promoting data utilization through Hackathon.

Keywords: Data Utilization, Hackathon, Event Report

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Experimental Evaluation of High-Speed File Transfer over JHPCN

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With the rapid growth of data amount, big data processing imposes a substantial burden on computation, storage, and communication in data centers. The file transfer tool is used to provide the users with the ease of transferring files across the network, e.g., between data centers. In practical long distance networks, the amount of packet loss is not negligible to seriously affecting the file transfer. In general, the file transfer tool is based on transmission control protocol (TCP) and user datagram protocol (UDP). To the best of our knowledge, however, no file transfer tools based on TCP and UDP have succeeded in higher throughput than 10 Gbps on long distance networks with packet loss. In this research, we introduce a high-speed data transfer protocol for inter-data center transport network, namely high-performance and flexible protocol 2 (HpFP2). The HpFP2 is an improved version of the HpFP and is more suitable for real network environments. To accommodate different usage scenarios, we complete four operating modes of HpFP2: aggressive, fair, fast-start, and modest modes. The aggressive mode is to maximize its own throughput without regard to fairness or network stability. The fair mode is to maintain the fairness among all network connections and balance the speed of each network connection by gradually increasing the amount of data transmitted until it finds the network’ s maximum carrying capacity. The fast-start mode is to improve the properties of fair mode by providing a fast and stable experience. The modest mode is to improve the estimation of the fair transmission rate and prevent the rate oscillation which is occurred by the aggressive mode. Based on HpFP2, we implement a file transfer tool, called high-performance copy (HCP), to improve file transfer performance over Japan high performance computing and networking (JHPCN). The performance of our file transfer tool is evaluated using real datasets collected from supercomputer resources. The results show that the HCP achieves notably better performance than the conventional tool for file transfer over JHPCN.

Keywords: High-Speed File Transfer, Big Data, JHPCN, HpFP

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Programming Environment of Visual IoT Tools Working on Single-Board Computer (Raspberry Pi) (2)

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The recent emergence of low-cost single board computers such as Raspberry Pi and Arduino, which are used as sensing devices with connectivity to Internet gateways and cloud services, has led to Internet of Things (IoT) architectures in the real world. Visual IoT is one of the classes of IoT that poses crucial end-to end challenges due to the need for sensing and processing of visual data. One of the significant roles of the visual IoT is information extraction from images by using image recognition techniques. In this paper, we present a programming environment of visual IoT on Raspberry Pi, and develop a couple of applications. The first one is an application for real-time information extraction and the second one is an augmented reality (AR)-oriented application. The performance of both applications is examined in outdoor fields using 4G LTE mobile networks to prove that our environment has a potential for many types of visual IoT devices.

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Real-Time Monitoring Technique of Earth Environment via Visual IoT

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Visual Internet of Things (IoT) is a class of IoT that collects rich visual data. In general, the visual IoT device is equipped with a video transmission equipment such as a camera. The involved technologies are advanced video transmission techniques and information extraction from images by image recognition techniques. However, since the video data size is larger than the sensor data size, one of the issues of visual IoT is high-performance video transmission in networks in which the bandwidths are limited. In this paper, we design and develop a real-time monitoring system using visual IoT device. Our system is based on a novel protocol, named high-performance video transmission (HpVT), for field monitoring via 4G LTE mobile networks. The performance of our system is evaluated in real fields to conclude that we can achieve full high-definition (full-HD) resolution video transmission with as high frame rate as 30 fps.

Keywords: Visual IoT, Mobile Network, High-Performance Video Transmission

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International Deployment of real-time web of Himawari (meteorological satellite) data: A case of mirroring to Philippines

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The third-generation meteorological satellites equipped with highly-improved imagers provide a large amount of Earth observation data. The Himawari-8 satellite is the first unit of the Japan Meteorological Agency's third-generation meteorological satellite. After its starting operation in 2015, there are many websites that provide remotely sensed images in real time. In general, the real-time and full-resolution websites are hard to be developed due to the large amount of data to be transferred. The Himawari-8 real-time web provided by the National Institute of Information and Communications Technology (NICT) is only a website that provides remotely sensed images with full resolution in real time. However, to reduce network traffic and increase the access speed of it from other countries out of Japan, mirror websites of each country are needed. This paper presents a mirroring system of the Himawari-8 real-time web. We propose a model for mirroring to avoid the CPU power consumption problem of big data processing in the mirror websites. In addition, we also introduce a file copy tool based on high-performance and flexible protocol (HpFP) to transfer meteorological satellite data between the Himawari-8 real-time web and the mirror websites. The contribution of this paper is to provide a cost-effective solution for the mirror websites. Our first target is an institution in Philippines (ASTI) connected via an international network, called Japan Gigabit Network (JGN) and the Asia Pacific Advanced Network (APAN). The results show that the proposed mirroring system is able to overcome the big data issue by eliminating the CPU power consumption in the mirror websites and transferring data files at high speed over the international network even under packet loss conditions. This suggests that our mirroring system has a potential for deployment in other Asian countries.

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Visualization of Himawari-8 observation data using high resolution animation: The case studies of CEReS, Chiba University, Japan

*Koichi Toyoshima[1], Atsushi Higuchi[1]

1. Center for Environmental Remote Sensing, Chiba University

Hiamwari-8 called as third generation geostationary satellite, equipped with a multispectral imager with a higher spatial resolution and a rapid observation frequency. The observation data amount is very large, not only handled as a still image, be handled and treated as an animation is useful to understand the observation event. In this presentation, in order to make full use of the advantages of wide-area high-definition observation data, we introduce the processing of animation for real-time monitoring display with 7K / 6K high-definition display consisting of multiple 4K monitors at Chiba University. We convert the case on environmental issues and notable weather phenomena in high-resolution video, and upload to YouTube. We also refer to efforts to educate and publicity of satellite observation cases.

Keywords: Geostationary , meteorological satellites, Environmental studies

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Performance evaluation of inter-node MPI parallel TensorFlow for massive learning data

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Recently machine learning (ML) achieves great works in the recognition, and it plays an essential role in the AI (artificial intelligence) area. In general, the learning data is one of the most critical keys for the ML since the feature extraction from each learning data affects strongly to the accuracy of recognition. Thus, the large amount of learning data is required for ML to avoid bias recognition. However, it takes a long time and needs many computer memory to learn from the massive data. In this talk, the inter-node MPI parallel TensorFlow is introduced.

TensorFlow is the one of ML framework developed by Google, and it is used in the world. Google has developed the inter-node parallel TensorFlow however it is not suitable for the supercomputer such as picking up the local computing node directly to participate in the calculation. To overcome this problem, Horovod MPI based TensorFlow has released by Uber, and it can use the MPI tuned for the supercomputer. As the collaboration of Cray and Kyoto University, more optimized MPI based TensorFlow which is called as CPE ML Plugin has been introduced to the supercomputer of Kyoto University. In this talk the performance evaluation of this MPI based TensorFlow.

Keywords: machine learning, inter-node parallel

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_45

[M-GI37] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University)

Increasingly large and complex data are produced by observations and numerical simulations in earth and planetary sciences. The target of this session is to discuss a broad range of practices and new knowledge of informatics, international standard and modelling, including techniques for large-scale data processing and numerical simulation, data preservation and publication, data transfer and collection and other data technologies with a vision to advance an emerging data-intensive science, namely "geoplanetary informatics".

[MGI37-P01] Publication of georeferenced polygon data to make JMA XML machine-readable

*Eizi TOYODA[1] (1.Administration Department, Japan Meteorological Agency)

[MGI37-P02] Development of a web system for search, browsing and download of Akatsuki's observation data

*Ko-ichiro SUGIYAMA[1], Kosei Murakoso[1], Kazuki Oomori[1,3], Takumi Aoki[1,4], Shin-ya Murakami[2] (1.National Institute of Technology, Matsue College, 2.ISAS/JAXA, 3.NTT DATA MHI Systems Corporation, 4.Mazda E&T)

[MGI37-P03] Large amount of data related to D/V Chikyu and science support activities

*Yukari Kido[1], Takamitsu Sugihara[1], Yoshinori Sanada[1], Tatsuya Murayama[1] (1.Japan Agency for Marine-Earth Science and Technology)

[MGI37-P04] Data delivery and visualization service for climate forecast data in the Arctic Ocean during R/V Mirai cruise MR18-05

*Takeshi Terui[1], Takeshi Sugimura[1], Liyanarachchi Waruna Arampath De Silva[2], Souichiro Sueyoshi[3], Jun Inoue[1] (1.National Institute of Polar Research, 2.The University of Tokyo, 3.Nippon Marine Enterprises)

[MGI37-P05] Improvement of mineral mapping accuracy by increasing spectral band and spatial resolutions of multispectral optical sensor imagery

*Katsuaki Koike[1], Nguyen Tien Hoang[1], Shuho Noda[2], Yukie Asano[2], Yuu Kawakami[2], Kazuo Masuda[2] (1.Laboratory of Environmental Geosphere Engineering, Department of Urban Management, Graduate School of Engineering, Kyoto University, 2.Japan Oil, Gas and Metals National Corporation (JOGMEC))

[MGI37-P06] Analysis of vessel status information of past research cruises and prediction of downtime for future cruise

*Yasuko Yamagishi[1], Ken Yatsu[2], Kazuhiko Kashiwase[2], Tetsuji Maki[2], Yuta Yamamuro[2,3], Hide Sakaguchi[1] (1.MAT, JAMSTEC, 2.MARITEC, JAMSTEC, 3.Nippon Marine Enterprises, Ltd.)

[MGI37-P07] Verification of an ocean monitoring system using a climate satellite "Himawari"

*YUUICHI KAGA[1], SHIGETO WATANABE[1] (1.Hokkaido Information University)

[MGI37-P08] Development of smooth area detection method for selection of landing site on a small body

Yuki Fujii[1], *Rie Honda[1], Tomokatsu Morota[4], yokota yasuhiro[2], ERI TATSUMI[3], Naoya Sakatani[2], Manabu Yamada[9], Shingo Kameda[5], Toru Kouyama[10], Hidehiko Suzuki[6], Chikatoshi Honda[7], Masahiko

Hayakawa[2], Kazuo Yoshioka[3], Yuichiro Cho[3], Yukio Yamamoto[2], Naru Hirata[7], Naoyuki Hirata[8], Hirotaka Sawada[2], Seiji Sugita[3] (1.Kochi University, 2.ISAS/JAXA, 3.University of Tokyo, 4.Nagoya University, 5.Rikkyo University, 6.Meiji University, 7.Aizu University, 8.Kobe University, 9.Chiba Institute of Technology, 10.National Institute of Advanced Industrial Science and Technology)

[MGI37-P09] Activity Report of Hackathon Event "SpaceHack 2019" for Utilization of Space Data

*Tsubasa Yumura[1], Satoshi Kikuchi[1], Tsutomu Nagatsuma[1], Ken T. Murata[1] (1.National Institute of Information and Communications Technology)

[MGI37-P10] Experimental Evaluation of High-Speed File Transfer over JHPCN

*Praphan Pavarangkoon[1], Ken T. Murata[1], Kazunori Yamamoto[1], Takamichi Mizuhara[2], Yuya Kagebayashi[2], Ayahiro Takaki[2], Kazuya Muranaga[3], Keiichiro Fukazawa[4] (1.National Institute of Information and Communications Technology, Tokyo, Japan, 2.CLEALINK TECHNOLOGY Co., Ltd., Kyoto, Japan, 3.Systems Engineering Consultants Co., Ltd., Tokyo, Japan, 4.Academic Center for Computing and Media Studies, Kyoto University, Kyoto, Japan)

[MGI37-P11] Programming Environment of Visual IoT Tools Working on Single-Board Computer (Raspberry Pi) (2)

*Takamichi Mizuhara[1], Ken T. Murata[2], Praphan Pavarangkoon[2], Somnuk Phon-Amnuaisuk[3], Kazunori Yamamoto[2], Kazuya Muranaga[4], Toshiki Aoki[1] (1.CLEALINK TECHNOLOGY CO., LTD., 2.National Institute of Information and Communications Technology, 3.Universiti Teknologi Brunei, 4.Systems Engineering Consultants Co., LTD.)

[MGI37-P12] Real-Time Monitoring Technique of Earth Environment via Visual IoT

*Kazunori Yamamoto[1], Ken T. Murata[1], Takamichi Mizuhara[2], Praphan Pavarangkoon[1], Kazuya Muranaga[3], Toshiki Aoki[2] (1.National Institute of Information and Communications Technology, 2.CLEALINK TECHNOLOGY Co., Ltd., 3.Systems Engineering Consultants Co.,LTD.)

[MGI37-P13] International Deployment of real-time web of Himawari (meteorological satellite) data: A case of mirroring to Philippines

Kazuya Muranaga[1], Praphan Pavarangkoon[2], Kazunori Yamamoto[2], *Ken T. Murata[2], Atsushi Higuchi[3] (1.Systems Engineering Consultants Co., LTD., 2.National Institute of Information and Communications Technology, 3.Chiba University)

[MGI37-P14] Visualization of Himawari-8 observation data using high resolution animation: The case studies of CEReS, Chiba University, Japan

*Koichi Toyoshima[1], Atsushi Higuchi[1] (1.Center for Environmental Remote Sensing, Chiba University)

[MGI37-P15] Performance evaluation of inter-node MPI parallel TensorFlow for massive learning data

*Keiichiro Fukazawa[1] (1.Academic Center for Computing and Media Studies, Kyoto University)

Publication of georeferenced polygon data to make JMA XML machine-readable

*Eizi TOYODA[1]

1. Administration Department, Japan Meteorological Agency

Japan Meteorological Agency (JMA) has developed an XML format to structurized replacement for traditional plain text bulletins in Japanese text (Kana-Kanji messages) used for alerting messages such as warnings and advisories. The JMA's XML format reduced ad-hoc parsing work of plain text, while the geolocation remained as issue. Messages issued for fixed geographical areas (like prefectures or municipalities) contain only code for the areas, and users had to prepare polygon data by the area's name for visualization.
January 2019, JMA published georeferenced polygon data (in shapefiles). Challenges will be presented during the session, including the selection of horizontal resolution and the clarification of geographical areas. JMA expects the polygon data expands the utilization of JMA's XML messages in other formats or in conjunction with other geospatial information.

Keywords: JMA XML, geospatial polygon data, open data

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Development of a web system for search, browsing and download of Akatsuki's observation data

*Ko-ichiro SUGIYAMA[1], Kosei Murakoso[1], Kazuki Oomori[1,3], Takumi Aoki[1,4], Shin-ya Murakami[2]

1. National Institute of Technology, Matsue College, 2. ISAS/JAXA, 3. NTT DATA MHI Systems Corporation, 4. Mazda E&T

Venus climate orbiter "Akatsuki" observes clouds of different altitudes using five cameras with narrowband filters at different wavelengths. The images taken by Akatsuki are published on NASA's Planetary Data System (PDS) [1] and AKATSUKI Science Data Archive [2] of ISAS/JAXA's Data ARchives and Transmission System (DARTS) [3] after a certain period of time has elapsed. However, because the images taken by each camera are archived in different directories on the websites, there is a problem that it is difficult to get an overview of data obtained by cooperatively observing with multiple wavelengths.

With this background in mind, we have been developed a web system named "Akatsuki Data Search" [4] using Ruby on Rails. Our system provides easy search, browsing and download of data published on the above sites. In order to investigate the three-dimensional motion of Venus atmosphere over time that is the purpose of the Akatsuki project, we implement a function to generate the image list page using observation program names and its execution times described in header of the data files. This function makes it possible to compare cloud images at different altitudes taken at the same time and to display time variation of cloud distribution at the same altitude. Furthermore, in order to response the request to search data by information not written in header of the data files (e.g. images used for an article), function of "my favorite" is implemented. This function makes it possible to save the names of favorite data files or search condition used to obtain the files and to share the favorites with users.

In our presentation, we will explain and demonstrate our system in detail.

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[3] Data ARchives and Transmission System (DARTS), https://www.darts.isas.jaxa.jp/

[4] Akatsuki Data Search, https://vco.epi.it.matsue-ct.jp/

Keywords: Venus climate orbiter "Akatsuki", Web System, big data

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Large amount of data related to D/V Chikyu and science support activities

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1. Japan Agency for Marine-Earth Science and Technology

It has been 14 years passed since deep drilling vessel "Chikyu" delivered to Japan Agency of Marine-Science and Technology Center (here after JAMSTEC) in July, 2005. D/V Chikyu is one of main drilling platforms in the frame work of International Drilling program which was cerebrated the just 50th anniversary by 2018. During the period, getting improvements of drilling technology, Chikyu performed remodel and reform aging laboratory equipment and a scientific support activity. Her drilling records are “16” expeditions, the number of days of more than 1000 days, 350 participants from 27 countries in scientific drilling project, 41 km drilling lengths, deepest water depth of 6,928.5 m (Exp.343), 101 drilling holes, 5.6 km cumulative collected core lengths, 1060 cores and more than 3,262.5 m of deepest hole records (Exp.358) since Exp.314 the first mission of IODP (as of February 2019). We are doing scientific services modeled after D/V Joides Resolution led by USA and investigating a questionnaire and request to the laboratory performed at the time of a sailing end of each time. Data management, a QC system and data delivery service to a researcher are being performed so that the quality of the data service may be also kept in a constant and to some amount of level. There are widely and many aspects of scientific support activities as carrying site survey, documentation and preparation for audit of scientific drilling, planning of stratigraphic inspection and data quality check. Wide range of activity as well as witness of operation, data process, delivery and report making support are carried out. Onboard scientific drilling workshop putting on the past data acquired so far at the same area, and new proposal system of Chikyu Shallow piston Core Program (SCORE) are running. Chikyu provides a realistic environment for researchers to concentrate on and throw themselves into research activities. A various categorized core schools for the next generation and other research field participants are also supporting. Logging schools are long running beyond 10 years and collaborating with Asian countries. The support activity with the enormous volume of data, the researcher and the engineer who surround "Chikyu" from the view point of scientific support are discussed and promoted deepened and more profoundly.

Keywords: Drilling Vessel Chikyu, IODP, Science Drilling Support

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Data delivery and visualization service for climate forecast data in the Arctic Ocean during R/V Mirai cruise MR18-05

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Understanding of the weather situation is the most important issue for observation cruse in the sea ice area. In particular, overviewed information of 1000 km scale is a good indication to determine a safe route and plan, and the weather forecast and observation data is required. However, limited satellite telecommunication line on the ship makes on-demand data delivery difficult. And more, if the compressed data would be sent via this line, a professional staff for decoding and visualizing the data must always be needed on the ship. In order to reduce these anxiety and burden, automatically system integrating these processes (delivery, decoding, and visualizing data) is needed. ADS (Arctic Data archive System) has been developed the new integrated system for the ship to delivery and visualize data, which is called VENUS (VEssele Navigator by Unitized Systems). This system has been implemented to R/V Mirai cruise in the Arctic Ocean since MR16-06. MR18-05 cruse was a winter observation in the Arctic Ocean, and we delivered 10 days weather forecast data produced byECMWF, and high resolution sea ice forecast model output from IcePOM developed in the University of Tokyo. Total size of delivered data via e-mail was reached to about 100 MB/day, and more than 100 e-mails were delivered to Mirai every day. Our system was always in a high load condition due to visualization processing. We need to In this research, we want to introduce technical performances and advantages of this system. For safe cruse, we must complete the transmission and visualization of such massive data by the scheduled time. Therefore, we devised a lot of solutions to solve the technical difficulties. In this research, we introduce what we did to solve these problems and discuss various issues of data distribution and processing in ship.

Keywords: Arctic Ocean, Ship Observation, IoT, Forecast Data, Visualization, Satellite communication

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Improvement of mineral mapping accuracy by increasing spectral band and spatial resolutions of multispectral optical sensor imagery

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Multispectral optical sensor images widely used in geologic remote sensing have covered all Earth land areas for a long time and vast data have been accumulated. However, their numbers of spectral bands are few (usually around ten) and spatial resolutions are relatively low, which decreases discrimination accuracy of mineral and rock types. Observation areas by hyperspectral imagery and high-resolution imagery are limited locally and costly. For this problem, this study aims to develop two transformation methods of general multispectral satellite imagery all over the scene into (1) hyperspectral imagery with many bands and (2) high spatial resolution imagery equivalent to the highest resolution level in the present geologic remote sensing, towards finally a simulation of hyperspectral, hyperresolution imagery for advanced exploration of metal and geothermal resources and precise monitoring of geologic environments. In this study, ASTER, AVIRIS, and WorldView-3 (WV-3) images were selected as representative multispectral (MS), hyperspectral (HP), and high spatial resolution (HSR) imagers, respectively. The spatial resolutions in the short-wave infrared region (SWIR), essential to discrimination of minerals, are ASTER: 30 m and WV-3: 7.5 m.

As for the first hyperspectral transformation, we use PHITA developed by the authors (Pseudo-Hyperspectral Image Transformation Algorithm: Hoang and Koike, 2017; 2018). This method is based on multiple regression model for correlations between MS and HP band reflectance data, and selects the best model through Bayesian model averaging. One pixel of MS image consists of several pixels of overlapped HP image (e.g., one pixel of ASTER = 4×4 pixels of WV-3 image). As for the second hyperresolution transformation, an assumption that a radiance at one pixel of MS image is summation of radiances at several, corresponding pixels of HSR image is set, and their relationship is quantified by a generalized additive model (Stasinopoulos et al., 2018) that is more versatile and rigorous than traditional multiple regression model.

A part of the Cuprite hydrothermal alteration area in the western United States for which ASTER, WV-3, and AVIRIS images were available was selected as training area for the two methods, and a principle of machine learning was adopted for the targeted Goldfield near Cuprite, a world-famous epithermal deposit area. An ASTER image in Cuprite was transformed into a pseudo-AVIRIS image by PHITA and their regression model was applied to an ASTER image of Goldfield. As the result, detection accuracies of hydrothermal alteration minerals such as alunite and kaolinite were largely increased. Four SWIR bands whose wavelengths were common between ASTER and WV-3 were used for the hyperresolution. By applying a correlation rule between the ASTER and WV-3 images obtained for Cuprite to Goldfield, the ASTER image of Goldfield was downscaled to the WV-3 resolution and consequently, mapping of minerals such as alunite was achieved more in detailed than the ASTER resolution. These two outcomes were verified by a ground-truth survey in 2018 and an XRD analysis of the samples by it, which demonstrates correctness and effectiveness of the proposed hyperspectral and hyperresolution methods.

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Stasinopoulos, M. D., Rigby, R. A., Bastiani, F. D. (2018) GAMLSS: A distributional regression approach. *Stat. Modelling*, v. 18, pp. 248-273.

Keywords: Hyperspectral imagery, Hydrothermal alteration mineral, Multiple regression model, Short-wave infrared region, Cuprite, Goldfield

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Analysis of vessel status information of past research cruises and prediction of downtime for future cruise

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Japan Agency for Marine-Earth Science and Technology (JAMSTEC) owns several research vessels and is responsible for the operation of the research cruise by these vessels. The ship time of research vessels belonging to JAMSTEC has declined over the last 10 years due to decrease in the number of vessels and the budget for research cruises. On the other hand, the occurrence of trench type large earthquake, global warming, and seabed resource exploration have increased the importance of the oceanic observation. Under these circumstances, it is indispensable to plan the most optimal research cruises to carry out the necessary oceanic observations. At present, JAMSTEC has to plan all research cruises for next fiscal year one year before. In order to perform the most effective research cruises, our project aims to provide useful information when planning future research cruise. Our project started in FY 2016. We first started to investigate the efficiency of the past research cruises. We have compiled time-sequence data of vessel status and performed observations in the past cruise, and estimated downtime for each cruise, which is a period when the observation or cruise is interrupted due to rough weather, machine trouble, etc. The downtime is one of the indicators for the efficiency of the research cruise. We also have developed database system to store the time-sequence data and information of each research cruises including downtime. The time-sequence data has been compiled based on E-mail sent from vessel to ground management office in the cruise. In E-mail, the information is written in text, ie in natural language. Therefore, the time-sequence data should be compiled by manually, it takes a lot of time to digitize it. Currently, we are also developing an application that automatically create the time-sequence data of vessel status and performed observation. Next, we have analyzed the downtime and the information of the past research cruises and searched for important factors that affect the downtime. And then, we have developed an application to predict the downtime of future cruises by using machine learning. In this study, we will introduce the analysis results of the downtime and the progress of the application development. Acknowledgments: we are grateful to Mr. Morisaki and Ms. Sada for their supports to make data stored into the database system.

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Verification of an ocean monitoring system using a climate satellite "Himawari"

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We have developed an application of ocean condition monitoring system with iPad and/or iPhone. The application can obtain the sea conditions and the catch amounts around Japan. We present some results of relation between the sea conditions and the catch amounts under the collaborations with fishermen in this presentation.

Keywords: meteorological satellite "Himawari", ocean monitoring, big data

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Development of smooth area detection method for selection of landing site on a small body

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1. Kochi University, 2. ISAS/JAXA, 3. University of Tokyo, 4. Nagoya University, 5. Rikkyo University, 6. Meiji University, 7. Aizu University, 8. Kobe University, 9. Chiba Institute of Technology, 10. National Institute of Advanced Industrial Science and Technology

Hayabusa2 arrived at asteroid Ryugu on June 2018 and scheduled to conduct touch-down to its surface. We have developed a smooth area detection method for selecting smooth area for landing on a small body such as an asteroid. The small dark or bright spot of 1 pixel scale which might be an boulder, or some obstacles are detected by subtracting the smoothed images via median filter from the raw images. Then the coverage of these possible boulder or obstacle pixels are calculated for a circular area which represents the footprint of the accuracy of the landing, and the area with the less coverage is selected as the safer area for landing. Furthermore, the method based on the clustering of texture of the small block area. Application to Ryugu Images obtained by Hayabusa2 ONC-T will be introduced in the presentation.

Keywords: automatic detection, smooth area, clustering, median filter

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Activity Report of Hackathon Event "SpaceHack 2019" for Utilization of Space Data

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1. National Institute of Information and Communications Technology

National Institute of Information and Communications Technology (NICT) accumulates various observation data about space in each research group. Some of these data are disclosed on the website. In order to promote the utilization of this data, we have planned the Hackaston event "SpaceHack 2019”. Hackathon is a collective term for events that creates systems and applications in a short period of about a few days, and is held numerous by voluntary organizations, companies, local governments, and so forth. SpaceHack 2019 recruited general participants outside NICT and held for two days. On the first day, after explaining the event overview and explaining the available data, we implement ideason to brush up ideas among participants. Based on the results of Ideason, articipants form a team develop until the afternoon on the second day. After the development, presentation, review, and recognition are carried out. SpaceHack provides participants with cloud system for scientific research “Science Cloud”, high speed R&D network testbed “JGN” and large scale emulation testbed “StarBED”. In our presentation, we will report the summary of SpaceHack 2019 and discuss the possibility of promoting data utilization through Hackathon.

Keywords: Data Utilization, Hackathon, Event Report

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Experimental Evaluation of High-Speed File Transfer over JHPCN

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With the rapid growth of data amount, big data processing imposes a substantial burden on computation, storage, and communication in data centers. The file transfer tool is used to provide the users with the ease of transferring files across the network, e.g., between data centers. In practical long distance networks, the amount of packet loss is not negligible to seriously affecting the file transfer. In general, the file transfer tool is based on transmission control protocol (TCP) and user datagram protocol (UDP). To the best of our knowledge, however, no file transfer tools based on TCP and UDP have succeeded in higher throughput than 10 Gbps on long distance networks with packet loss. In this research, we introduce a high-speed data transfer protocol for inter-data center transport network, namely high-performance and flexible protocol 2 (HpFP2). The HpFP2 is an improved version of the HpFP and is more suitable for real network environments. To accommodate different usage scenarios, we complete four operating modes of HpFP2: aggressive, fair, fast-start, and modest modes. The aggressive mode is to maximize its own throughput without regard to fairness or network stability. The fair mode is to maintain the fairness among all network connections and balance the speed of each network connection by gradually increasing the amount of data transmitted until it finds the network’ s maximum carrying capacity. The fast-start mode is to improve the properties of fair mode by providing a fast and stable experience. The modest mode is to improve the estimation of the fair transmission rate and prevent the rate oscillation which is occurred by the aggressive mode. Based on HpFP2, we implement a file transfer tool, called high-performance copy (HCP), to improve file transfer performance over Japan high performance computing and networking (JHPCN). The performance of our file transfer tool is evaluated using real datasets collected from supercomputer resources. The results show that the HCP achieves notably better performance than the conventional tool for file transfer over JHPCN.

Keywords: High-Speed File Transfer, Big Data, JHPCN, HpFP

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Programming Environment of Visual IoT Tools Working on Single-Board Computer (Raspberry Pi) (2)

*Takamichi Mizuhara[1], Ken T. Murata[2], Praphan Pavarangkoon[2], Somnuk Phon-Amnuaisuk[3], Kazunori Yamamoto[2], Kazuya Muranaga[4], Toshiki Aoki[1]

1. CLEALINK TECHNOLOGY CO., LTD., 2. National Institute of Information and Communications Technology, 3. Universiti Teknologi Brunei, 4. Systems Engineering Consultants Co., LTD.

The recent emergence of low-cost single board computers such as Raspberry Pi and Arduino, which are used as sensing devices with connectivity to Internet gateways and cloud services, has led to Internet of Things (IoT) architectures in the real world. Visual IoT is one of the classes of IoT that poses crucial end-to end challenges due to the need for sensing and processing of visual data. One of the significant roles of the visual IoT is information extraction from images by using image recognition techniques. In this paper, we present a programming environment of visual IoT on Raspberry Pi, and develop a couple of applications. The first one is an application for real-time information extraction and the second one is an augmented reality (AR)-oriented application. The performance of both applications is examined in outdoor fields using 4G LTE mobile networks to prove that our environment has a potential for many types of visual IoT devices.

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Real-Time Monitoring Technique of Earth Environment via Visual IoT

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Visual Internet of Things (IoT) is a class of IoT that collects rich visual data. In general, the visual IoT device is equipped with a video transmission equipment such as a camera. The involved technologies are advanced video transmission techniques and information extraction from images by image recognition techniques. However, since the video data size is larger than the sensor data size, one of the issues of visual IoT is high-performance video transmission in networks in which the bandwidths are limited. In this paper, we design and develop a real-time monitoring system using visual IoT device. Our system is based on a novel protocol, named high-performance video transmission (HpVT), for field monitoring via 4G LTE mobile networks. The performance of our system is evaluated in real fields to conclude that we can achieve full high-definition (full-HD) resolution video transmission with as high frame rate as 30 fps.

Keywords: Visual IoT, Mobile Network, High-Performance Video Transmission

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International Deployment of real-time web of Himawari (meteorological satellite) data: A case of mirroring to Philippines

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1. Systems Engineering Consultants Co., LTD., 2. National Institute of Information and Communications Technology, 3. Chiba University

The third-generation meteorological satellites equipped with highly-improved imagers provide a large amount of Earth observation data. The Himawari-8 satellite is the first unit of the Japan Meteorological Agency's third-generation meteorological satellite. After its starting operation in 2015, there are many websites that provide remotely sensed images in real time. In general, the real-time and full-resolution websites are hard to be developed due to the large amount of data to be transferred. The Himawari-8 real-time web provided by the National Institute of Information and Communications Technology (NICT) is only a website that provides remotely sensed images with full resolution in real time. However, to reduce network traffic and increase the access speed of it from other countries out of Japan, mirror websites of each country are needed. This paper presents a mirroring system of the Himawari-8 real-time web. We propose a model for mirroring to avoid the CPU power consumption problem of big data processing in the mirror websites. In addition, we also introduce a file copy tool based on high-performance and flexible protocol (HpFP) to transfer meteorological satellite data between the Himawari-8 real-time web and the mirror websites. The contribution of this paper is to provide a cost-effective solution for the mirror websites. Our first target is an institution in Philippines (ASTI) connected via an international network, called Japan Gigabit Network (JGN) and the Asia Pacific Advanced Network (APAN). The results show that the proposed mirroring system is able to overcome the big data issue by eliminating the CPU power consumption in the mirror websites and transferring data files at high speed over the international network even under packet loss conditions. This suggests that our mirroring system has a potential for deployment in other Asian countries.

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Visualization of Himawari-8 observation data using high resolution animation: The case studies of CEReS, Chiba University, Japan

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1. Center for Environmental Remote Sensing, Chiba University

Hiamwari-8 called as third generation geostationary satellite, equipped with a multispectral imager with a higher spatial resolution and a rapid observation frequency. The observation data amount is very large, not only handled as a still image, be handled and treated as an animation is useful to understand the observation event. In this presentation, in order to make full use of the advantages of wide-area high-definition observation data, we introduce the processing of animation for real-time monitoring display with 7K / 6K high-definition display consisting of multiple 4K monitors at Chiba University. We convert the case on environmental issues and notable weather phenomena in high-resolution video, and upload to YouTube. We also refer to efforts to educate and publicity of satellite observation cases.

Keywords: Geostationary , meteorological satellites, Environmental studies

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Performance evaluation of inter-node MPI parallel TensorFlow for massive learning data

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Recently machine learning (ML) achieves great works in the recognition, and it plays an essential role in the AI (artificial intelligence) area. In general, the learning data is one of the most critical keys for the ML since the feature extraction from each learning data affects strongly to the accuracy of recognition. Thus, the large amount of learning data is required for ML to avoid bias recognition. However, it takes a long time and needs many computer memory to learn from the massive data. In this talk, the inter-node MPI parallel TensorFlow is introduced.

TensorFlow is the one of ML framework developed by Google, and it is used in the world. Google has developed the inter-node parallel TensorFlow however it is not suitable for the supercomputer such as picking up the local computing node directly to participate in the calculation. To overcome this problem, Horovod MPI based TensorFlow has released by Uber, and it can use the MPI tuned for the supercomputer. As the collaboration of Cray and Kyoto University, more optimized MPI based TensorFlow which is called as CPE ML Plugin has been introduced to the supercomputer of Kyoto University. In this talk the performance evaluation of this MPI based TensorFlow.

Keywords: machine learning, inter-node parallel

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 301B 3F

[M-GI37] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University), Chairperson:Susumu Nonogaki, Ken Murata(National Institute of Information and Communications Technology)

Increasingly large and complex data are produced by observations and numerical simulations in earth and planetary sciences. The target of this session is to discuss a broad range of practices and new knowledge of informatics, international standard and modelling, including techniques for large-scale data processing and numerical simulation, data preservation and publication, data transfer and collection and other data technologies with a vision to advance an emerging data-intensive science, namely "geoplanetary informatics".

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MGI37-01] Exploration of the earth environment using meteorological satellite "Himawari"

*ryuta ando[1], Shigeto Watanabe[1], Ken T. Murata[2] (1.Hokkaido Information University, 2.National Institute of Information and Communications Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MGI37-02] Kochi radar network composed of compact X-band radars

*Koji Sassa[1], Toshiaki Takaki[2], Ken T Murata[3] (1.Natural Science Cluster, Kochi University, 2.Furuno Electric Co.,Ltd., 3.National Institute of Information and Communication Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MGI37-03] Rain Echo Classification by Deep Learning Using Observation Big Data of Phased Array Weather Radar

*Shinsuke Satoh[1], Hiroshi HANADO[1], Seiji Kawamura[1], Tomohiko Konno[1], Michiaki Iwazume[1], Shigenori Otsuka[2], Takemasa Miyoshi[2] (1.National Institute of Information and Communications Technology, 2.RIKEN Center for Computational Science)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MGI37-04] Communication area map of LoRa in Chikuma city using community bus services

*Kohei Mizuani[1], Ken T. Murata[1], Yoshiaki Muroyama[1], Kazunori Yamamoto[1], Kazuya Muranaga[2], Takamichi Mizuhara[3], Praphan Pavarangkoon[1] (1.National Institute of Information and Communications Technology, 2.Systems Engineering Consultants Co., LTD., 3.CLEALINK TECHNOLOGY Co.,Ltd.)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MGI37-05] Development of an inexpensive and small balloon observation device, and its application in observing the Earth's upper atmosphere

*Taku Takada[1], Yui Sasaoka[1], Shiya Ueta[1], Ken T. Murata[2], Hidehiko Suzuki[3] (1.National Institute of Technology, Kochi College, 2.National Institute of Information and Communications Technology, 3.Meiji University)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

Discussion

Exploration of the earth environment using meteorological satellite "Himawari"

*ryuta ando[1], Shigeto Watanabe[1], Ken T. Murata[2]

1. Hokkaido Information University, 2. National Institute of Information and Communications Technology

We investigated the earth environment using the meteorological satellite "Himawari 8" and artificial intelligence (AI). Generally, AI needs images more than tens of thousands for the recognition of image. However, we used spectral data extracted for each pixel of spectral image at 16 wavelengths (visible to infrared) from "Himawari 8" for AI learning in this research. By characterizing the spectral data and the earth environment, we developed an AI system to recognize the earth environment and the environmental changes. This study is the first time to learn the spectral data of 16 wavelengths for each pixel in AI and to investigate the earth environment. Moreover, this AI model uses only hundreds of data sets of 16 wavelength for learning the earth environment in all space and time such as latitude / longitude, day / night, season. Our developed AI using spectral data of the meteorological satellite "Himawari" is useful for predicting typhoons and drift ice, etc. The AI is also useful to investigate planetary environment as well as the earth environment.

Keywords: Meteorological Satellite Himawari-8, Spectral Data, 16 wavelengths, Artificial intelligence

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Kochi radar network composed of compact X-band radars

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1. Natural Science Cluster, Kochi University, 2. Furuno Electric Co.,Ltd., 3. National Institute of Information and Communication Technology

Kochi Prefecture is the heaveist rain area in Japan. Heavy rain events and hazardous winds causing disaster frequently occur there. But, only one C-band Doppler radar of JMA and two C-band polarymetric radars in high mountains cover the area and warm rain near ground cannot be observed by these radars well.
Then we constructed high resolution radar network composed of 6 compact X-band polarymetric radars settled in Kochi Prefecture and started continuous observation. These radars are solid state type. The observation range and beam width of one radar is 80 km and 2 deg., respectively. The other 5 radar observes within 30 km and these beam width is 2.7 deg. They make volume scan at relatively low elevation angles every 1 minute and 1 km CAPPI data are obtained from them. These big data are corrected in science cloud in NICT via wonms settled at each radar sights. We can show the 1km CAPPI network data about 4minutes after the observation.
We succeeded to observe the organised convection systems, such as linear rain bands by 5 radars when torrential rain occurred in the west Japan in early July, 2018. We also observed the vortices in parent clouds causing tornadoes in detail.

Keywords: radar network, compact radar, cloud

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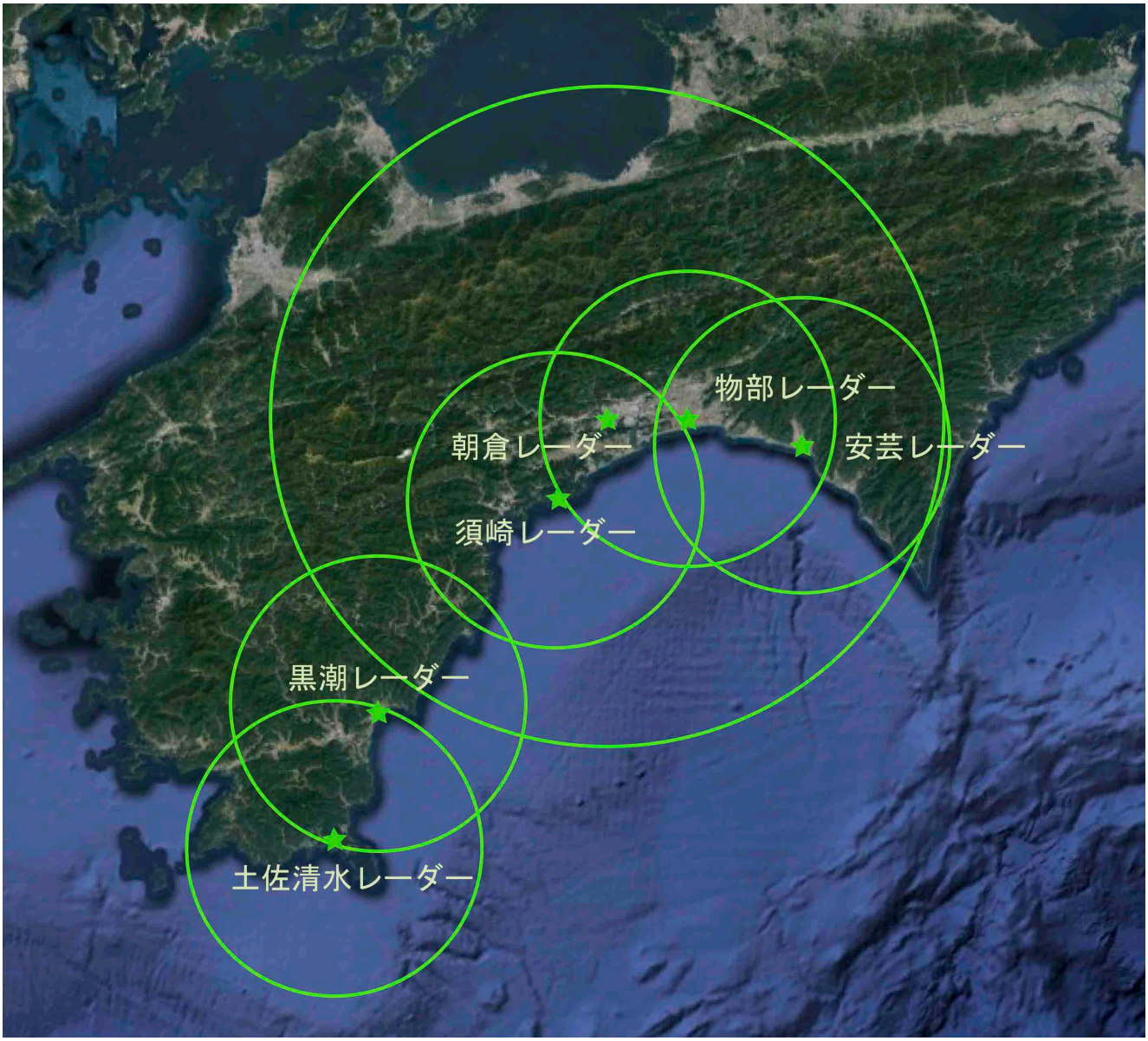

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Rain Echo Classification by Deep Learning Using Observation Big Data of Phased Array Weather Radar

*Shinsuke Satoh[1], Hiroshi HANADO[1], Seiji Kawamura[1], Tomohiko Konno[1], Michiaki Iwazume[1], Shigenori Otsuka[2], Takemasa Miyoshi[2]

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The phased array weather radar (PAWR) was developed with the goal of early detection and prediction of sudden weather disasters caused by torrential rain and tornados and gusts. The PAWRs installed in Suita, Kobe, Okinawa, are operated regularly and generate three-dimensional data every 30 seconds. The observation big data exceeding 2 PB has been accumulated. The real-time observation data is used by the smartphone app "3D Rain Watch" and "RIKEN 3D Nowcast" and the research results of data analysis and data assimilation have been published, but the accurate prediction of torrential rain could not be realized. Also, many of archived past data cannot be used effectively. In recent years, it has become an era when a computer can realize judgment using a deep learning which has developed rapidly. Although deep learning needs to be learned using a large amount of data, new results which cannot obtain by human data analysis, are expected. In this study, we aim to automatic extraction of the precursor phenomena leading to torrential rain prediction by using deep learning technology called convolutional neural network (CNN). As the first attempt, we try to classify rain echoes from two-dimensional image data of rainfall distribution observed by PAWR. In terms of rain echo classification, the difference in rainfall type, convective or stratiform, is also important, but in addition to that, we attempt to classify rainfall distribution patterns such as isolated, linear, and mass.
The original data of PAWR observation is archived as binary data of polar coordinates, but for this deep learning we use a quick look (QL) image showing the horizontal distribution of the radar echo intensity of the altitude of 2 km which is published in real time on the Web Page. The number of accumulated QL images of Kobe PAWR reaches 4 million in total, but more than half are QL images without rain in the radar observation range of 120 km in diameter and cannot be used for rain echo classification. In order to perform deep learning, it is necessary to label the QL images, but it is not easy for a man to manually label 10000 images. Fortunately, in order to create a rain summary graph on the Web, numerical information of the average rainfall amount, maximum rainfall amount, and rainfall area corresponding to each QL image is saved as a text file. After rough labeling using the information, eventually it is judged by human eyes. Finally, we classify into eight categories of strong / weak isolated convective, linear convective, mass convective, stratified, and no rainfall. Using more than 900 samples in each category from 50 days observation data in June, July, August 2016, we repeatedly learned them about 1000 times using a simple 7-layer CNN, and as a result it was able to perform rain echo classification with an accuracy of 72%. We believe it is possible to increase accuracy by removing ambiguous labeling samples or using a more complicated CNN network. In the future, we want to advance research that leads to heavy rain prediction by using three-dimensional data and time-series data.

Keywords: Phased Array Weather Radar, Observation Big Data, Deep Learning, Rain Echo Classification

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Communication area map of LoRa in Chikuma city using community bus services

*Kohei Mizuani[1], Ken T. Murata[1], Yoshiaki Muroyama[1], Kazunori Yamamoto[1], Kazuya Muranaga[2], Takamichi Mizuhara[3], Praphan Pavarangkoon[1]

1. National Institute of Information and Communications Technology, 2. Systems Engineering Consultants Co., LTD., 3. CLEALINK TECHNOLOGY Co.,Ltd.

Internet of Things (IoT) where data of many sensors are collected through the Internet is one of important social infrastructure technologies. Various sorts of regional IoT technologies were developed and expected to be tools for the enhancement of public services and the resolution of public issues in the community thorough use and application of the collected data. We conducted communication environment measurement of private LoRa (Long Range), which is one of the low-power wide area (LPWA) communication technologies in Chikuma city, Nagano prefecture, Japan, using community bus services. In this experiment, we set up LoRa relay stations at three locations in the city: the Koshoku governmental building (the northern part of the city), the Togura governmental building (the southern part of the city), and the Amenomiya drainage plant (the eastern part of the city). In addition, beacon transmitters were installed in the community buses (nine routes in all). The location and time information were transferred from the routes of the buses to the NICT Science Cloud servers in real time through the relay stations. Experimental results are summarized in an area map, indicating that we succeeded in communicating in most of the bus routes and confirmed the possibility of covering the entire city by the LPWA. Even in the insensitive area of this experiment, the communication will become possible by adding several relay stations.

Keywords: IoT, LPWA, LoRa, area map

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Development of an inexpensive and small balloon observation device, and its application in observing the Earth's upper atmosphere

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1. National Institute of Technology, Kochi College, 2. National Institute of Information and Communications Technology, 3. Meiji University

In this presentation we will outline the development of an inexpensive and small balloon observation device and its use in observing the Earth's atmosphere, from the troposphere to the stratosphere. By enclosing helium in a rubber balloon used for meteorological observation, it is possible to make the observation device fly in a region extending beyond the troposphere to the stratosphere. We have been developing balloon observation devices and carrying out balloon-based observation experiments with students since 2014. In 2018, we aimed to develop an observation system capable of monitoring the flight path of the balloon devices, by installing three to four ground stations (including mobile stations) and using communication equipment based on Long Range (LoRa) modulation of the 920 MHz band. We conducted experiments with LoRa communication equipment with a line-of-sight of up to 28 km, which confirmed that communication via LoRa modulation can be successfully applied in balloon monitoring. Furthermore, we are currently developing a balloon detachment system and, by separating the balloon near the designated altitude, we can shorten the distance traveled in the horizontal direction and lengthen the observation time at the optimum altitude. In the current balloon observation system, we aim to develop its use for various atmospheric observations, mainly for classifying the following three observation sequences: (1) when reaching the stratosphere (about 25 km altitude), the balloon bursts and deploys a parachute; (2) when reaching an altitude of about 15 km, when air density becomes sufficiently low, the balloon detaches and deploys a parachute, (3) when reaching an altitude of between 7 and 10 km, after completely passing through the tropospheric cloud layer, the balloon detaches and deploys a parachute. We hope to develop a balloon observation system suitable for use with various observation targets.

Keywords: Balloon observation, small balloon, upper atmosphere, stratosphere, troposphere, LoRa communication

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-GI General Geosciences, Information Geosciences & Simulations

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 301B 3F

[M-GI37] Earth and planetary informatics with huge data management

convener:Ken T. Murata(National Institute of Information and Communications Technology), Rie Honda(Department of Science and Technology, System of Natual Science, Kochi University), Susumu Nonogaki(Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology), Takeshi Horinouchi(Faculty of Environmental Earth Science, Hokkaido University), Chairperson:Rie Honda, Ken Murata(National Institute of Information and Communications Technology)

Increasingly large and complex data are produced by observations and numerical simulations in earth and planetary sciences. The target of this session is to discuss a broad range of practices and new knowledge of informatics, international standard and modelling, including techniques for large-scale data processing and numerical simulation, data preservation and publication, data transfer and collection and other data technologies with a vision to advance an emerging data-intensive science, namely "geoplanetary informatics".

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MGI37-06] Introduction of “ChOWDER”: A tiled display driver that augment large scale visualization of geoscience.

*Tomohiro Kawanabe[1], Kenji Ono[2], Atsushi Higuchi[3], Koichi Toyoshima[3], Kazunori Yamamoto[4], Kazuya Muranaga[5], Ken T. Murata[4] (1.RIKEN , 2.Kyushu Univ., 3.Chiba Univ., 4.NICT, 5.Systems Engineering Consultants Co.,LTD.)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MGI37-07] Data archive and integrated data analysis tools developed by ERG Science Center

*Tomoaki Hori[1], Yoshizumi Miyoshi[1], Masafumi Shoji[1], Mariko Teramoto[1], Tzu-Fang Chang[1], Satoshi Kurita[1], Shoya Matsuda[2], Yasunori Tsugawa[1], Tomonori Segawa[1], Norio Umemura[1], Nozomu Nishitani[1], Takako Kondo[1], Hiroyasu Yonaha[1], Yukinaga Miyashita[3], Kunihiro Keika[4], Kanako Seki[4], Yoshimasa Tanaka[5], Iku Shinohara[2] (1.Institute for Space-Earth Environmental Research, Nagoya University, 2.Japan Aerospace Exploration Agency / Institute of Space and Astronautical Science, 3.Korea Astronomy and Space Science Institute, 4.Graduate School of Science, The University of Tokyo, 5.National Institute of Polar Research)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MGI37-08] KOSEN-1 CubeSat mission for Jupiter's radio science

*Kazumasa Imai[1], Nobuto Hirakoso[2], Taku Takada[1], Kentarou Kitamura[3], Masafumi Imai[4], KOSEN-1 Team[5], Charles A. Higgins[6], James R. Thieman[7], NASA Radio JOVE Team[8] (1.Department of Social Design Engineering, National Institute of Technology, Kochi College, 2.Department of Mechanical Engineering, National Institute of Technology, Gunma College, 3.Department of Mechanical and Electrical Engineering, National Institute of Technology, Tokuyama College, 4.University of Iowa, 5.KOSEN-1 Team, 6.Middle Tennessee State University, 7.University of Maryland Baltimore County, 8.NASA Radio JOVE Team)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MGI37-09] Problems of acquisition of auroral image data and data processing

*Ryuho Kataoka[1], Ken T. Murata[2], Yoshizumi Miyoshi[3], Herbert Akihito Uchida[1], Yoko Fukuda[4], Atsushi Yamashita[5], Masayuki Tanaka[6] (1.National Institute of Polar Research, 2.National Institute of Information and Communication Technology, 3.Nagoya University, 4.National Institute for Environmental Studies, 5.The University of Tokyo, 6.Tokyo Institute of Techonology)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MGI37-10] Innovative progress in ground observation of snow crystals and weather conditions by citizen science

★Invited Papers

*Kentaro Araki[1] (1.Meteorological Research Institute)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MGI37-11] Efforts of landslide susceptibility mapping for slope disaster risk evaluation

*Kazunori Hayashi[1], Akihiko Wakai[2], Go Sato[3], Takashi Kimura[4], Ken T. Murata[5], Akino Watanabe [2] (1.Okuyama Boring Co., Ltd., 2.Gunma University, 3.Teikyo Heisei University, 4.National Research Institute for Earth Science and Disaster, 5.National Institute of Information and Communications Technology)

Introduction of “ChOWDER”: A tiled display driver that augment large scale visualization of geoscience.

*Tomohiro Kawanabe[1], Kenji Ono[2], Atsushi Higuchi[3], Koichi Toyoshima[3], Kazunori Yamamoto[4], Kazuya Muranaga[5], Ken T. Murata[4]

1. RIKEN , 2. Kyushu Univ., 3. Chiba Univ., 4. NICT, 5. Systems Engineering Consultants Co.,LTD.

1. Introduction

The Tiled display is a method that tiles multiple physical displays to provide large pixel space. Demand for tiled displays is expected to increase in the research fields that deal with data requiring large-scale, high-resolution visualization such as geoscience. In this paper, we first describe the outline of "ChOWDER", a system that realizes tiled display in software, and then introduce example applications in geoscience. Finally, we will explain how to obtain ChOWDER software.

2. ChOWDER

ChOWDER is an open source tiled display driver which is jointly conducting research and development between RIKEN and Kyushu University, running on Windows, Linux, and macOS. It has a unique feature called "Virtual Display Area "(Hereinafter referred to as" VDA ") which is not available in other tiled display drivers.

The VDA is a logical two-dimensional space managed by the ChOWDER server, and the display contents can be arranged at arbitrary positions and magnification ratios here. In addition, since the display device which is the content display destination can also be placed on the VDA at an arbitrary position/magnification ratio, by using this, it is possible to build a tiled display with high flexibility such as mixed displays with different resolutions and aspect ratios.

Since the necessary software for the display device is only an ordinary Web browser such as Firefox, Chrome, there is no need to install special software or expensive graphics board corresponding to multiple display connection. When the Web browser connects to the ChOWDER server, it is in the full-screen display mode, and the whole pixels of the physical display is used as the display area of ChOWDER. In other words, it functions as (a part of) the ChOWDER tiled display as long as it is a device on which the ordinary web browser runs.

Also, the device of the display content sending side needs only the Web browser. Static content such as text file, image file, PDF file and streaming contents such as movie file, the desktop screen of sending side device, web camera can be displayed on ChOWDER tiled display.

In addition, ChOWDER can mirror tiled displays of multiple sites. By lay over the display device positions of each site on the above VDA, it is possible to share and display contents between multiple sites.

With these features, we believe ChOWDER is a flexible software that can build a tiled display with a relatively small investment.

3. Use cases

Fig.2 shows a 16K resolution image by visualization software HIVE developed by RIKEN and display it to a tiled display consisting of twelve 4K display (15,360 ×6,480 total pixel resolution) through ChOWDER. It is parallel computation result of climate simulator NICAM used the whole system(88,128CPU) of "K computer". HIVE has the function of directly transmitting the rendering result image to ChOWDER, hence it is possible to simultaneously observe the entire overview and detailed parts without thinning out the high-resolution data generated by the large-scale simulation using the supercomputer.

Fig.3 shows a tiled display (17,280 ×5,120 total pixels) composed of 36 full HD displays owned by the

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Center for Environmental Remote Sensing, Chiba University. It displays two of AMATERASS (http://amaterass.nict.go/ index.html) screens and an image from Himawari 8 provided by the National Institute of Information and Communications Technology. The screen of AMATERASS is streamed from the users PC screen to ChOWDER, and when AMATERASS is operated on the PC, it also follows the display on the tiled display at the same time. Since PCs of multiple users can be displayed as contents sending sources and respective information can be displayed side by side on one tiled display, bird's-eye view-ish collaborative work can be performed.

4. Software distribution

ChOWDER is an open source software distributed under the BSD 2 clause license and can be used free of charge for academic and commercial use. You can download software and user documentation from GitHub. (https://github.com/SIPupstreamDesign/ChOWDER)

Keywords: Tiled Display, Visualization, Web Browser, Collaborative work

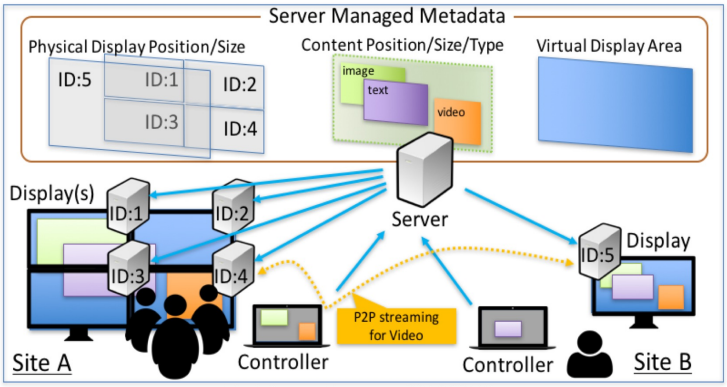

Fig.1 System Diagram of ChOWDER

Fig.2 A Displaying Example of a 16K Resolution Image

Fig.3 A Displaying Example of Multiple Application Windows Streaming from Multiple Users PC.

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Data archive and integrated data analysis tools developed by ERG Science Center

*Tomoaki Hori[1], Yoshizumi Miyoshi[1], Masafumi Shoji[1], Mariko Teramoto[1], Tzu-Fang Chang[1], Satoshi Kurita[1], Shoya Matsuda[2], Yasunori Tsugawa[1], Tomonori Segawa[1], Norio Umemura[1], Nozomu Nishitani[1], Takako Kondo[1], Hiroyasu Yonaha[1], Yukinaga Miyashita[3], Kunihiro Keika[4], Kanako Seki[4], Yoshimasa Tanaka[5], Iku Shinohara[2]

1. Institute for Space-Earth Environmental Research, Nagoya University, 2. Japan Aerospace Exploration Agency / Institute of Space and Astronautical Science, 3. Korea Astronomy and Space Science Institute, 4. Graduate School of Science, The University of Tokyo, 5. National Institute of Polar Research

The ERG (Exploration of energization and Radiation in Geospace) is a Japanese geospace exploration project. Its core component is the ERG satellite, also known as Arase, an inner magnetosphere satellite with the full set of particle and field instruments launched on December, 2016. The ERG project consists of the satellite observation team, the ground-based network observation team, and the integrated data analysis/simulation team. Besides these research teams, ERG Science Center (ERG-SC) has been organized and operated by ISAS/JAXA and ISEE/Nagoya University from the very beginning of the ERG project. Since then, ERG-SC has been playing an essential role in managing the data center for all kinds of scientific data as well as promoting close collaborations of the three teams and other research projects, maximizing scientific output from the ERG project. For studies of Geospace, where different plasma populations are interacted with each other via cross-energy and cross-regional coupling processes, the integrated data analysis combining various kinds of data sets is key to comprehensive understanding of multiscale dynamical processes. For these purposes, the level-2 (calibrated, in physical unit) science data and higher level data products of the Arase satellite as well as the ground observation network data are archived in the Common Data format (CDF), which was developed by NASA, and are basically open freely to the international science community from the ERG-SC data repository. The integrated data analysis tool is also developed on the basis of the Space Physics Environment Data Analysis Software (SPEDAS), which is de facto standard software of the space physics community, enabling the data users to combine Arase data with the other satellite, ground, modeling data seamlessly in plotting and manipulating them.

Keywords: Arase satellite, Radiation belt, Space plasma

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KOSEN-1 CubeSat mission for Jupiter's radio science

*Kazumasa Imai[1], Nobuto Hirakoso[2], Taku Takada[1], Kentarou Kitamura[3], Masafumi Imai[4], KOSEN-1 Team[5], Charles A. Higgins[6], James R. Thieman[7], NASA Radio JOVE Team[8]

1. Department of Social Design Engineering, National Institute of Technology, Kochi College, 2. Department of Mechanical Engineering, National Institute of Technology, Gunma College, 3. Department of Mechanical and Electrical Engineering, National Institute of Technology, Tokuyama College, 4. University of Iowa, 5. KOSEN-1 Team, 6. Middle Tennessee State University, 7. University of Maryland Baltimore County, 8. NASA Radio JOVE Team

Since the discovery of Jupiter's decametric radio emissions in 1955, important details of its radiation mechanism have not yet been elucidated. In order to investigate the beaming structure of Jupiter's radio emission to clarify aspects of the emission mechanism, we plan to launch a 2U-size CubeSat for observation of Jupiter's radio waves and observe simultaneously in outer space and on the ground. The purpose of this project is to measure the emission delay time by using a correlation analysis method. The delay time can be measured by the correlation analysis of waveform data obtained by simultaneous observations of Jupiter's radio S-bursts between this satellite and the ground. If the beam of Jupiter's radio S-bursts is moving together with the rotation of Jupiter, we can calculate a time difference of about 70 milliseconds at the baseline length of 8000 km. Using the proposed simultaneous observations, it is possible to test whether the Jovian S-bursts are emitted like a 'beacon', rotating with Jupiter's magnetic field and sweeping by the Earth, or like a 'flashlight', an instantaneous emission with a 0 millisecond time delay. This information is very important to determine the nature of the Jupiter's radio emission mechanism.

Our application for the launch of a 2U-CubeSat named KOSEN-1 by a JAXA Epsilon rocket was selected on Dec. 12, 2018, as a CubeSat candidate for JAXA's innovative satellite technology demonstration program. This rocket launch including our KOSEN-1 project is scheduled at the end of 2020. The worldwide ground-based observations together with the KOSEN-1 satellite will be supported by the NASA Radio JOVE project, an education and outreach program for planetary radio astronomy.

The KOSEN-1 project is supported by the Coordination Funds for Promoting AeroSpace Utilization of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), JAPAN.

Keywords: CubeSat, Jupiter radio, decametric wave, beam structures

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Problems of acquisition of auroral image data and data processing

*Ryuho Kataoka[1], Ken T. Murata[2], Yoshizumi Miyoshi[3], Herbert Akihito Uchida[1], Yoko Fukuda[4], Atsushi Yamashita[5], Masayuki Tanaka[6]

1. National Institute of Polar Research, 2. National Institute of Information and Communication Technology, 3. Nagoya University, 4. National Institute for Environmental Studies, 5. The University of Tokyo, 6. Tokyo Institute of Techonology

We have obtained various types of auroral image data in various shooting styles around the world. In this lecture, we will report on several problems of data processing. Experiments currently undertaken include real-time image processing of aurora with possibility of 4K / 8K streaming, acquisition of continuous image data of 100 fps by the EMCCD camera and the data release, and photographing of aurora from unmanned aircraft using a small infrared camera. In the past attempts using commercially available digital cameras, outreach-purpose experiments include 4K-3D dome-master time-lapse images and 20K-VR shooting, scientific-purpose experiments include automatic detection of auroras to control high-speed imaging of aurora.

Keywords: aurora, image processing, high-speed imaging

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Innovative progress in ground observation of snow crystals and weather conditions by citizen science

*Kentaro Araki[1]

1. Meteorological Research Institute

To improve forecasts of snowfall events, a better understanding of the horizontal distribution of precipitation types and the microphysical properties of snow clouds is required. Observations of cloud microphysical properties, however, has been limited because of the sparse observation network. Recently, ground observations of precipitation types are performed by citizen science approaches especially in United States. In this study, ground observations of snow crystals and weather conditions are conducted by citizen science in Japan, and we would like to introduce recent progress in ground observation study and discuss the potentialities and challenges of citizen science big data.

The Meteorological Research Institute (MRI) has conducted the "#KantoSnowCrystal Project" to collect images of snow crystals from citizens during snowfall events in the Kanto and Koshin regions in Japan from November 2016. Smartphone cameras were used to capture the images, which were mainly collected through social networking services. Through the project, we were able to establish an easy method for snow crystal observation and data collection. More than 10,000 snow crystal images were gathered throughout the 2016-2017 winter, of which 73% were analyzable. In the case of heavy snowfall event in the Kanto plain on 22 January 2018, more than 40,000 snow crystal images were gathered in only a day. The #KantoSnowCrystal Project thereby realized spatiotemporally ultra-dense observations of snow crystals in these metropolitan areas, and the observation dataset should contribute to investigations of snowfall mechanisms in these areas and the verification and improvement of numerical weather models, etc. The amount of data, however, varied considerably between heavily populated central urban areas and less-populated inland areas. As the number of the data became enormous, it was also a challenge to efficiently collect and analyze the big data.

To investigate the characteristics of citizen science data, an existing dataset obtained from citizens of the "10-minute weather report" provided by Weathernews Inc. was examined. In this data, weather types are classified into 15 categories based on citizens' experiences. From the result of the examination of about 60 million weather reports from 2012 to 2017, it was found that the number of citizen science data and the population were proportional and the number of the data highly depended on human activity. The number of the data tended to increase in the case of rare and severe storm events in the metropolitan areas, such as heavy snowfall events in Tokyo in winter. From the comparison of the data between citizen science and the Japan Meteorological Agency, about 90 % of the weather types of rain and snow agreed in each data. The coincidence rate of weather type, however, declined for graupel and mixed rain and snow. These results indicate that citizen science data is effective in the snowfall study in the metropolitan areas and greatly contributes to the snowfall study if there is objective information such as photographs of precipitation.

Based on the results of these studies, the #KantoSnowCrystal Project of the MRI has started to use the App "SoraWatch by 3D AmagumoWatch" (https://sora-watch.3d-amagumo.com/) for smartphone and tablet devices and to gather the information of weather type and snow depth images in addition to snow crystals from all over Japan from February 2019. Citizen scientists are able to select 16 weather types (sunny, cloudy, rain, mixed rain and snow, snow, ice pellet, hail, thunder, tornado, fog, frost, burnt sky,

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rainbow, cloud iridescence, halo and arc, and the other), 11 snow crystal types, and snow depth with these photographs on the App. The database is also available for the purpose of scientific research and education. Big data obtained from citizen scientists through the App has possibility to contribute to not only the snowfall study but also various meteorological research fields, educations, commercials, etc.

Keywords: citizen science, big data, meteorological observation

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Efforts of landslide susceptibility mapping for slope disaster risk evaluation

*Kazunori Hayashi[1], Akihiko Wakai[2], Go Sato[3], Takashi Kimura[4], Ken T. Murata[5], Akino Watanabe[2]

1. Okuyama Boring Co., Ltd., 2. Gunma University, 3. Teikyo Heisei University, 4. National Research Institute for Earth Science and Disaster, 5. National Institute of Information and Communications Technology

We introduce the current situation and efforts of the landslide susceptibility mapping method required for risk evaluation of slope disasters in this presentation.

The type of ladnslide movement is controlled by the geological and geomorphological factors. For example, shallow-seated landslides and highly fluidized landslides frequently occur on slope covered by unconsolidated volcanic sediments. Moreover, in Sedimentary rock regions with continuously bedding plane structure, large translational slides prone to occur on dip slope, while shallow-seated landslides prone to occur on steep cliffs of the anti-dip slope. In other words, the factors of data used for landslide susceptibility mapping and their weighting depend to the type of landslide movement at each slope, and on the geological and geomorphological conditions at each region.

On the other hand, rainfall indices such as effective rainfall and soil water index are used for announcement of the landslide disaster alert in Japan, but it does not sufficiently consider geographical and geomorphological conditions. For this reason, the spatial resolution as an evaluation unit is only 5 km square, and issues are still remained for landslide risk evaluation on each slope units and classification of landslide susceptibility areas. In addition, it is generally difficult to evaluate large-scale, deep-seated landslides, which are caused by complicated geological structures and underground hydrological conditions.

In this presentation, as a case study of the landslide susceptibility mapping considering geological and geomorphological factors, the activity evaluation of the landslide slopes using the AHP method, development of susceptibility mapping method for earthquake-induced landslides, and heavy rainfall-induced landsides in the volcanic regions will be introduced. A new slope stability evaluation method using a simple prediction model for shallow groundwater level rising will be introduced as well.

Keywords: landslide, slope, heavy rainfall, earthquake, disaster, susceptibility mapping

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 302 3F

[M-AG41] Dynamics of radionuclides emitted from Fukuchima Dai-ichi Nuclear Power Plant in the environment

convener:Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Daisuke Tsumune(Central Research Institute of Electric Power Industry), Chairperson:Yoshio Takahashi(東京大学), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba)

The Great East Japan Earthquake caused the severe accident in TEPCO Fukushima dai-ichi nuclear power plant (FDNPP), leading to emission of huge amount of radionuclides to the environment. They have been transported and diffused by atmospheric motion, depositing them to soil and vegetation. Deposited radionuclides are dynamically shifted in the earth environment; atmosphere, soil, inland water, ocean, and ecosystem. To understand this dynamic shift in the environment and for the long-term prediction of the disaster by the radionuclides, investigation and discussion based on not only the earth sciences including ecology but also on the radiochemistry and other related sciences. In this session, various efforts to understand the dynamic behavior of radionuclides emitted from FDNPP accident in the earth system as well as to predict their influences on the environment. It is expected that this session will offer a good opportunity to discuss radionuclides in the earth environment from wide aspect and to exchange information in various research fields.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MAG41-01] Investigation on basic physical and chemical properties of radio-Cs micro particles

*Yasuhito Igarashi[1], Kazuyuki Kita[2], Yukihiko Satou[3], Tomoaki Okuda[4], Yoshinari Abe[5], Keisuke Sueki[6], SHINOHARA ATSUSHI[7], Kazuhiko Ninomiya[7], Tsutomu Ohtshuki[1], Koichi Takamiya[1] (1.Institute for Integrated Radiation and Nuclear Science, Kyoto University, 2.Graduate School of Science and Engineering, Ibaraki University, 3.Collaborative Laboratories for Advanced Decommissioning Science, Japan Atomic Energy Agency, 4.Department of Applied Chemistry, Keio University, 5.Faculty of Science,Tokyo University of Science, 6.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, 7.Graduate School of Science, Osaka University)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MAG41-02] Dynamics of radioactive microparticles released from the Fukushima nuclear plant: heating and dissolution characteristics

★Invited Papers

*Taiga Okumura[1], Noriko Yamaguchi[2], Terumi Dohi[3], Kenso Fujiwara[3], Kazuki Iijima[3], Toshihiro Kogure[1] (1.The University of Tokyo, 2.National Agriculture and Food Research Organization, 3.Japan Atomic Energy Agency)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MAG41-03] Dynamics of atmospheric ^{131}I just after the Fukushima accident related to ^{137}Cs by analysis of published data

*Haruo Tsuruta[1], Yuichi Moriguchi[2], Teruyuki Nakajima[3] (1.Remote Sensing Technology Center of Japan, 2.The University of Tokyo, 3.Japan Aerospace Exploration Agency)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MAG41-04] Distribution of ^{237}Np and Plutonium isotope in terrestrial environment in Fukushima Prefecture

*Miho Fukuda[1], Zheng Jian[1], yamazaki Shinnnosuke[1], Tatsuo Aono[1] (1.National Institute for Quantum and Radiological Science and Technology, National Institute of Radiological Science)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MAG41-05] Study on deposition of ^{134}Cs and ^{137}Cs from atmosphere to freshwater environment using a mountainous lake, Lake Haruna in Gunma Prefecture, Japan

*Seiya Nagao[1], Shouhei Miyasaka[2], Shun Watanabe[3], Kyuma Suzuki[3], Shinya Ochiai[1] (1.Institute of Nature and Environmental Technology, Kanazawa University, 2.Graduate School of Natural Science and Technology, Kanazawa University, 3.Gunma Prefectural Fisheries Experimental Station)

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MAG41-06] Spatial variability of radiocesium deposition through the tree canopy via branchflow and stemflow

*Zul Hilmi Saidin[1], Yuichi Onda[2], Hiroaki Kato[2], Momo Kurihara[2], Kazuki Nanko[3], Delphis F. Levia[4] (1.Graduate School of Life and Environmental Sciences, University of Tsukuba, Tsukuba, Ibaraki, Japan, 2.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, Tsukuba, Ibaraki, Japan, 3.Department of Disaster Prevention, Meteorology and Hydrology, Forestry and Forest Products Research Institute, Tsukuba, Ibaraki, Japan, 4.Departments of Geography, University of Delaware, Newark, Delaware, USA)

Investigation on basic physical and chemical properties of radio-Cs micro particles

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The 2011 Fukushima Daiichi Nuclear Power Plant (F1NPP) accident caused several significant releases of radioactive particulates into the environment.The physical and chemical properties of these particles, which have not been known before,have been an area of significant study. It is suggested that these fine particulates could also remain,in significant amounts,inside the nuclear reactor cores where the accidents occurred. Though appropriate samples cannot currently be obtained from the inside of the stricken reactor cores, radioactive particles collected near to the site serve as a valuable evidence for elucidation of the accident events for each reactor unit explosion and as micro-scale samples of the residual fuel debris inside the reactors. Study of these particles can help to better establish an acceptable procedure for decommissioning (collection of molten fuel, etc., decontamination inside the reactor, safety of workers, etc.). Thus, it is necessary to investigate the physical and chemical properties using advanced micro-scale analytical methods, at the same time as examining effective separation and collection methods for the radioactive particles based on the obtained property information. This will all contribute to risk reduction of the whole "decommissioning" plan. Thus, we started the analysis of such radioactive particles by using the state-of-the-art technologies such as micro-X-ray analysis, Kelvin force microscopy, induced flourescent microscopy, etc. along with radiochemical analysis.

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Dynamics of radioactive microparticles released from the Fukushima nuclear plant: heating and dissolution characteristics

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A significant amount of radiocesium was released due to the Fukushima Daiichi Nuclear Power Plant accident in March 2011, causing radioactive contamination in east Japan. Most of the radiocesium is believed to have been released in a gaseous state, descended with rainwater and sorbed mainly by clay minerals in soil. On the other hand, spherical microparticles substantially consisting of silicate glass (radiocesium-bearing microparticle, CsMP) were also released from the damaged reactors. CsMPs are generally spherules of a few microns in diameter and contain Cl, K, Fe, Zn, Mn, Rb, Sn, and Cs in silicate glass. Since CsMPs have very high radioactivity per particle compared with soil particles sorbing radiocesium, the influence of radiation on their vicinity is a concern. However, the knowledge about dynamics of CsMPs in the environment is still limited and required urgently. Here, we report heating and dissolution characteristics of CsMPs.

Incineration of radioactive waste including CsMPs is under consideration for volume reduction. Therefore, we collected CsMPs and heated in the air in order to investigate their thermal behavior. As a result of heating treatment, the radioactivity of CsMPs gradually decreased from 600 ˚C and almost disappeared when heated up to 1000 ˚C. Scanning electron microscope (SEM) examination revealed that the morphology of CsMPs did not change even after heating at 1000 ˚C, but Cl and alkaline elements such as Cs and K were diffused away from CsMPs. The internal structure of CsMPs after heating was also investigated using transmission electron microscopy (TEM). Fe, Zn and Sn originally dissolved in the glass matrix were crystallized to oxide particles inside the CsMPs. Furthermore, when CsMPs were heated together with weathered granite soil collected in Fukushima, the radiocesium released from CsMPs was adsorbed by soil particles. These results of heating experiments suggested that highly radioactive particles such as CsMPs do not remain in the waste incinerated at a sufficiently high temperature.

Although CsMPs have been reported as “insoluble” particles thus far, they should be gradually dissolved in the environment because they substantially consist of silicate glass. We conducted dissolution experiments using CsMPs collected from the environment and investigated the dissolution behavior and lifetime of CsMPs. CsMPs were incubated in three kind of solutions, namely pure water, artificial seawater, and hydrochloric acid, under various temperature conditions, and the dissolution rate of CsMPs was estimated from the decrease in radioactivity. Furthermore, the activation energy for dissolution was calculated from the Arrhenius plot, resulting in 65 and 88 kJ/mol for pure water (pH is ~5.2 due to absorption of carbon dioxide in the atmosphere) and seawater, respectively. The calculated dissolution rate at 13 ˚C (approximate average temperature in Fukushima) is ~10 times larger in seawater than in pure water, and CsMPs are expected to be completely dissolved in seawater within ~10 years. This suggests that most of the CsMPs that fell into the sea immediately after the accident have already been disappeared. SEM observation of the CsMPs before and after dissolution in pure water revealed that their size was decreased and their spherical shapes were considerably altered without maintaining geometry. In the case of the CsMPs dissolved in seawater, plate-like secondary minerals rich in Fe and Mg were precipitated around the CsMPs to form a crust, and glass matrix was dissolved inside the crust. In addition, when CsMPs were incubated in hydrochloric acid with pH adjusted to 3, the radioactivity decreased considerably at the beginning, but ceased to change with time. A layer mostly consisting of SiO_2 was formed on the surface of the CsMPs, which may become a passive layer inhibiting dissolution.

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Keywords: microparticle, silicate glass, cesium, thermal characteristics, dissolution, Fukushima nuclear plant accident

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Dynamics of atmospheric ^{131}I just after the Fukushima accident related to ^{137}Cs by analysis of published data

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The spatio-temporal distribution of atmospheric ^{131}I just after the Fukushima Daiichi Nuclear Power Plant (FD1NPP) accident has not been understood due to the very limited measurements, compared to those of atmospheric ^{137}Cs and to many datasets of ^{131}I deposition density measured in east Japan. Accordingly, current estimates of internal exposure from inhalation have large uncertainty. The purpose of this study is to clarify the behavior of atmospheric ^{131}I in east Japan just after the accident, analyzing all the published data in the east Fukushima and Kantou areas. In the Kantou area, we mainly analyzed the data measured at JAEA-Nuclear Science Research Institute (NSRI) in Tokai (Ohkura et al., 2012). In the east Fukushima area, we used the data measured by Ministry of Education, Culture, Sports, Science and Technology (MEXT, 2012), by US Department of Energy (DOE)/National Nuclear Safety Administration (DOE/NNSA, 2011), and by Tokyo Electric Power Company (TEPCO, 2011) who measured on the sites of FD1NPP and Fukushima Daini Nuclear Power Plant (FD2NPP). The particulate/aerosol ^{131}I(g) and volatile/gaseous ^{131}(a) concentrations were decay-corrected to March 11, 2011 to normalize all the data due to the short half-life time of 8 days (the symbol of * is used). The major results are as follows. (1) For most of the dataset, particulate radionuclides were collected on the first filter (HE-40T or HE-40TA), and gaseous radionuclides were collected on the second filter cartridge (CHC-50 impregnated with 10% of TEDA) to increase in the collection efficiency of gaseous ^{131}I. The ^{137}Cs concentrations were detected on not only the first filter but also the second filter. After checking the data at NSRI in detail, we used the ^{137}Cs data only on the first filter mainly due to any contamination of measurement/sampling system (Ohkura et al., 2013; Tsuruta et al., to be submitted), while we used the ^{131}I data collected on both of the first and second filters. (2) The ratios of ^{131}(a+g)*/^{137}Cs in radioactive plumes were divided to three groups of A (10), B (75), and C (360). In addition, the ratios of ^{131}I(a)*/^{131}I(a+g)* were also divided to the same three groups. (3) These differences were caused by each plume, regardless of the measurement sites located in east Fukushima or Kantou area. Radionuclides in the A group were estimated to be emitted from Unit 2 and/or Unit 3, because the ratio of 10 was nearly equal to the inventory data of 9.7 (Unit 2) and 9.2 (Unit 3) by Nishihara et al.(2012). In contrast, the ratios in groups B and C were much higher than in group A. (4) The extremely high ratios of ^{131}(a+g)* /^{137}Cs in Group C measured from the afternoon of March 21 to March 25 were possibly caused by a new emission event after water supply to FD1NPP, such as the one proposed by Hidaka and Ishikawa (2014). This new event should be studied in future, although Group C has not been focused until now.

Keywords: Fukushima Daiichi Nuclear Power Plant, Atmospheric 131I, Ratios of 131I/137Cs, Effect of water supply

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Distribution of ^{237}Np and Plutonium isotope in terrestrial environment in Fukushima Prefecture

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After the accident at the Fukushima Dai-ichi Nuclear Power Station (FDNPS) happened in March 2011, large amounts of radionuclides released from the FDNPS into the atmosphere and marine environments.The total amounts of ^{134}Cs and ^{137}Cs, which are volatile materials, released from the accident were estimated as 18 PBq and 15 PBq, respectively. In contrast, those of ^{238}Pu,^{239}Pu and^{240}Pu, which are non-volatile materials, amounts were estimated as 0.0019 PBq, 0.0000032 PBq and 0.0000032 PBq and these amounts were not many compared to abundance before the accident (Report of Japan government to the IAEA Ministerial Conference on Nuclear safety, 2011). ^{241}Pu, half-life of which is about 14 year, detected in forest litter samples at some stations collected in April and May, 2011 and it is suggested that these samples were originated from the FDNPS accident also using the results of ^{240}Pu/^{239}Pu and^{241}Pu/^{239}Pu atomic ratio (Zheng et al., 2013). It is possible to identify origin to Pu and Np isotopes using not only Pu isotope atomic ratio such as ^{240}Pu/^{239}Pu and^{241}Pu/^{239}Pu but also ^{237}Np/^{239}Pu atomic ratio. Shozugawa et al (2012) reported that many radionuclides including^{239}Np in terrestrial environment soil and pine leaf collected in front of FDNPS and Iiidate Villege were measured. Other than Shozugawa et al (2012), reports for Np in Environment after the FDNPS accident was almost nothing. In this study, we discussed spatial distributions and origin for Neptunium (Np) and Pulutonium (Pu) based on the results of the Neptuniumand plutonium atom ratios (^{237}Np/^{239}Pu,^{240}Pu/^{239}Pu, ^{241}Pu/^{239}Pu) in soil samples collected in Fukushima Prefecture.Collected soil samples were air-dried,and then, ashed using muffle furnace at 450˚C at least 4 hours to decompose the organic matter (Wang et al., 2015). 0.57 pg of ^{242}Pu was used as recovery tracer for^{237}Np and Pu isotopes. Then, the anion-exchange resin AG MP-1M was used separated of ^{237}Np and Pu isotopes from u, Th and other interfaces (details for Haung et al. prepared).^{237}Np and Pu isotope measured using the Sector-Field ICP-MS. The ^{237}Np activity concentrations in soil samples were 1/100-1/1000 values compared to those of ^{239}Pu and ^{240}Pu. The rough profiles for these all radionuclide decreased with increasing core depth. Both ^{237}Np/^{239}Pu and ^{240}Pu/^{239}Pu atomic ratios were generally within global fallout ranges. Hereafter, it is necessary to elucidate factor controlling a values of outside the range in some layer were outside value.

This work was partially supported by Research and Development to Radiological Sciences in Fukushima Prefecture.

Keywords: Fukushima Dai-ichi Nuclear accident, 237Np, Pu isotope

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Study on deposition of ^{134}Cs and ^{137}Cs from atmosphere to freshwater environment using a mountainous lake, Lake Haruna in Gunma Prefecture, Japan

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The Great East Japan Earthquake occurred on 11 March 2011 and damaged the Fukushima Daiichi Nuclear Power Plant (FDNPP) seriously. Through the FDNPP accident, a large amount of radiocesium was released to the environment. It is important to elucidate the short-term and long-term impacts of the accident on terrestrial environments.

This study investigated the deposition of ^{134}Cs and ^{137}Cs at a mountainous lake, Lake Haruna, which is located at 1084 m height in Gunma Prefecture, Japan. The lake has a small inflow stream and one outflow river with watershed of relatively high radiocesium accumulation area. The lake sediments were collected at two sites from northern part (HR1) and central part (HR2) of the lake by using a gravity corer in September 2015. The sediment core samples were sectioned for 1 cm interval. The sediment core was also collected at HR3 from central part of the lake in October 2017. After freeze-drying of the sectioned samples, the radioactivity of ^{134}Cs and ^{137}Cs were measured by a low background Ge detector of Low Level Radioactivity Laboratory, Kanazawa University and shows as Bq/kg in dry-sediment basis at the sampling date.

Radioactivity of ^{134}Cs and ^{137}Cs ranged from D.L. to 2,922 Bq/kg and from D.L. to 34,000 Bq/kg, respectively. Two peaks of the radioactivity are observed for the HR1 sediments at 2-3 cm and 5-6 cm depth in core. One distinct peak of the radioactivity of ^{134}Cs and ^{137}Cs is observed at 3-4 cm depth in the core of HR2. Maximum of the radioactivity is also detected for the HR3 sediment core (2,920 and 23,760 Bq/kg) at 4-5 cm depth. The sedimentation rate based on ^{210}Pb for the HR1, HR2 and HR3 was 0.14, 0.031and 0.026 $g/cm^2/y$, respectively. The higher sedimentation rate at HR1 shows two peaks, but lower sedimentation rate at HR2 and HR3 show one peak of radiocesium concentration. However, the inventory of ^{134}Cs is almost constant (2.1-2.3 $x10^4$ Bq/m^2) for the three sampling sites. Two major deposition was observed in the middle of March and the early of April 2011 from the monitoring data of air gamma-ray dose rate at Takasaki and the fallout analysis of radiocesium at Maebashi in Gunma Prefecture. These results suggest that the accumulation of rediocesium at Lake Haruna mainly results from atmospheric deposition and shows short-term deposition to the bottom sediment at early stage of the accident.

Keywords: lake sediment, sedimentation rate, radiocesium

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Spatial variability of radiocesium deposition through the tree canopy via branchflow and stemflow

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This study aims to clarify the spatial variability radiocesium deposition through the tree canopy via branchflow and stemflow in the aftermath of the Fukushima Dai-ichi Nuclear Power Plant accident. Working in both a coniferous forest (*Cryptomeria japonica*, young Japanese cedar stands, mean height is 10.9 m, mean DBH is 0.560 m) and a mixed deciduous broadleaved forest (*Quercus serrata*, Japanese oak stands, mean height is 14.3 m, mean DBH is 0.789 m), we investigated the fate of radiocesium transported by branchflow from upper and lower portions of canopy and deposited by stemflow at trunk-based. Particular attention was paid to the leachable radiocesium at the tree canopy and the mechanism of radiocesium transport via stemflow and branchflow. In addition, we used isotopes to clarify the signature of evaporation loss via branchflow and stemflow on its routing through the canopy. Significant variability of ^{137}Cs concentration was detected among the sampling periods and differed between the two forests, with the oak stand generally exhibiting higher a ^{137}Cs concentration than the cedar stand. The preliminary results further revealed that the ^{137}Cs concentration was larger from dead foliage as compared to mixed and young foliage at the branchflow of cedar stand. Radiocesium leached more in lower stemflow of the trunk compared to upper trunk stemflow, possibly due to the increased residence time of stemflow on the lower reaches of the trunk. We also found that the isotopic composition of branchflow was generally enriched in δ^{18}O and δD compared to open rainfall and throughfall. However, the differences in enrichment between branchflow and stemflow remain unclear. Canopy architecture and canopy cover affected the cycling of radiocesium in stemflow and branchflow by foliage storage and washout capacity.

Keywords: Radiocesium leaching, Isotopic composition, Stemflow and branchflow, Coniferous and broadleaved forests, Canopy architecture, Canopy cover

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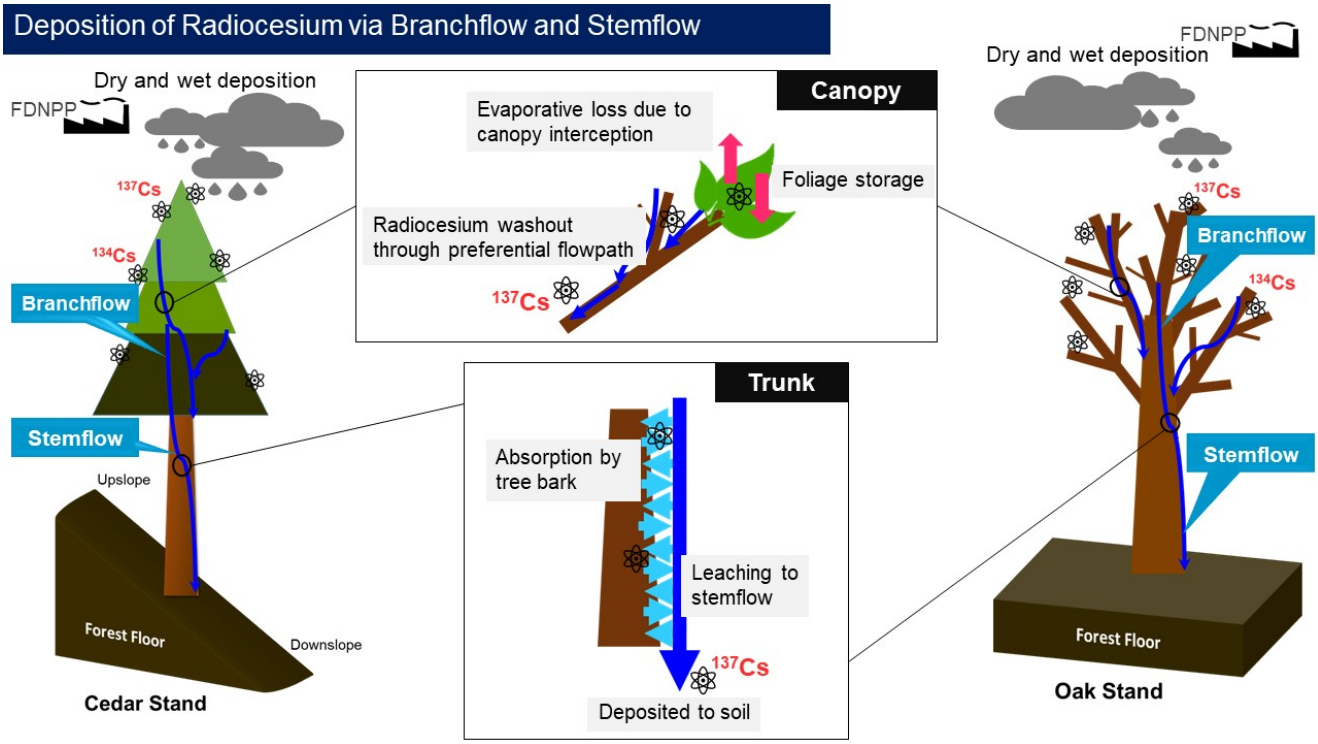

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 302 3F

[M-AG41] Dynamics of radionuclides emitted from Fukuchima Dai-ichi Nuclear Power Plant in the environment

convener:Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Daisuke Tsumune(Central Research Institute of Electric Power Industry), Chairperson:Kazuyuki Kita(Ibaraki University), Daisuke Tsumune(Central Research Institute of Electric Power Industry)

The Great East Japan Earthquake caused the severe accident in TEPCO Fukushima dai-ichi nuclear power plant (FDNPP), leading to emission of huge amount of radionuclides to the environment. They have been transported and diffused by atmospheric motion, depositing them to soil and vegetation. Deposited radionuclides are dynamically shifted in the earth environment; atmosphere, soil, inland water, ocean, and ecosystem. To understand this dynamic shift in the environment and for the long-term prediction of the disaster by the radionuclides, investigation and discussion based on not only the earth sciences including ecology but also on the radiochemistry and other related sciences. In this session, various efforts to understand the dynamic behavior of radionuclides emitted from FDNPP accident in the earth system as well as to predict their influences on the environment. It is expected that this session will offer a good opportunity to discuss radionuclides in the earth environment from wide aspect and to exchange information in various research fields.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MAG41-07] Temporal changes in vertical distributions of radiocesium in forest soils after the FDNPP accident

★Invited Papers

*Junko Takahashi[1], Daichi Hihara[1], Takuya Sasaki[1], Yuichi Onda[1] (1.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MAG41-08] Change of sediment sources in suspended sediments due to surface decontamination in the Niida river catchment area affected by the Fukushima Daiichi nuclear power plant accident

*Yuichi Onda[1], Yuki Yamanaka[1], Yoshifumi Wakiyama[2], Keisuke Taniguchi[3], Takaaki Kubo[1] (1.Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba, 2.Institute of Environmental Radioactivity, Fukushima University, 3.Fukushima Prefectural Centre for Environmental Creation)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MAG41-09] Neasrshore transport of suspended radiocesium In the Fuksima Coast derived from Niida River induced by Typhoon Wipha

*Natsuki Tokunaga[1], Yusuke Uchiyama[1], Daisuke Tsumune[2], Masatoshi Yamada[5], Yutaka Tateda[2], Yukari Ito[3], Takashi Ishimaru[3], Yutaka Watanabe[7], Ken Ikehara[4], Miho Fukuda[6] (1.Kobe University, 2.Central Research Institute of Electric Power Industry, 3.Tokyo University of Marine Science and Technology, 4.National Institute of Advanced Industrial Science and Technology, 5.Hirosaki University, 6.National Institute of Radiological Sciences, 7.Hokkaido University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MAG41-10] Particle size distribution and radiocesium concentration in suspended particles within the high turbidity layer at near sea bottom off Fukushima prefecture

*Hideki Kaeriyama[1], Naoki Furuichi[2], Kouichi Sugimatsu[3], Yuya Shigenobu[1], Shizuho Miki[1], Takami Morita[1], Daisuke Ambe[1], Tadafumi Ichikawa[1] (1.National Research Institute of Fisheries Science, Japan Fisheries Research and Education Agency, 2.National Research Institute of Fisheries Engineering, Japan Fisheries Research and Education Agency, 3.Seikai National Research Institute, Japan Fisheries Research and Education Agency)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MAG41-11] Fukushima-derived radiocesium in the subarctic region of the North Pacific Ocean in the summer of 2017

★Invited Papers

*Yuichiro Kumamoto[1], Michio Aoyama[2], Yasunori Hamajima[3], Akihiko Murata[1] (1.Japan Agency for Marine-Earth Science and Technology, 2.Fukushima University, 3.Kanazawa University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MAG41-12] **Temporal and spatial variations of radiocaesium in the East China Sea and Sea of Japan until 2018**

*Michio Aoyama[1], Yayoi Inomata[2], Yasunori Hamajima[2] (1.Institute of Environmnetal Radioactivity, Fukushima University, 2.Institute of Nature and Environmental Technology, Kanazawa University)

Temporal changes in vertical distributions of radiocesium in forest soils after the FDNPP accident

*Junko Takahashi[1], Daichi Hihara[1], Takuya Sasaki[1], Yuichi Onda[1]

1. Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba

After the Fukushima Dai-ichi Nuclear Power Plant accident on March 2011, several studies including our own showed that the downward migration of ^{137}Cs from litter to mineral soil is more rapid in forests in Fukushima than in forests affected by the Chernobyl accident. Therefore, the downward migration within mineral soil layers is more important in predicting long-term dynamics of ^{137}Cs in forest ecosystems in Fukushima. In this study, temporal changes in the detailed vertical distribution of ^{137}Cs in litter and soil layers for 7 y (2011–2018) at three forest sites (Mixed Forest, Mature Cedar forest and Young Cedar forest) were investigated in Kawamata town, Yamakiya district to quantify the downward migration of radiocesium.

The soil samples were taken in 5 mm increments between 0–5 cm, 1.0 cm increments between 5–10 cm, and 5.0 cm increments between 10–20 cm using a scraper plate. From 2017, the saturation water under litter, 5 cm, 10 cm and 20 cm depth of soil layers were collected using tension-free lysimeter to estimate the amount of downward migration by soluble radiocesium in saturation water. The radioactivity of ^{137}Cs in the samples was determined by gamma-ray spectrometry.

For the Young Cedar site, the total inventory of ^{137}Cs in the litter and soil layers gradually increased with time owing to deposition from the canopy, whereas temporal changes in the total ^{137}Cs inventories were not clear for the Mixed Forest and Mature Cedar sites. The ^{137}Cs concentrations and inventories in the litter layer exponentially decreased with time for all sites, with more than 80–95% of the ^{137}Cs deposited on the forest floor distributed in the mineral soil layer by 2018. As the downward migration from litter to mineral soil progressed, the ^{137}Cs concentration in a few cm of mineral soil surface gradually increased and became higher than the ^{137}Cs concentration in the litter within 2–3 y of the accident. In the Mature Cedar site, the amount of downward migration of soluble radiocesium from litter layer to mineral soil surface was estimated at 0.60 kBq m^{-2} from Aug. 2017 to July 2018 and about 7% of total downward migration that was calculated from temporal changes in the vertical distribution of radiocesium. Both concentration and flux of radiocesium in saturation water were higher in summer than in winter. Because the dissolved organic carbon showed similar trend with radiocesium, it was suggested that radiocesium in litter and mineral soil was dissolved and penetrated downward with the decomposition of litter and soil organic matters.

The ^{137}Cs concentration in mineral soil layers exponentially decreased with depth throughout survey period, and an exponential equation fitted well. The relaxation depth of ^{137}Cs concentration in mineral soil layers estimated by the exponential equation were constantly increasing in the Mature and Young Cedar sites with 0.08 cm y^{-1}. In contrast, there was no temporal increase in the relaxation depth in the Mixed Forest site, although the percentage of ^{137}Cs inventory in subsurface soil layers deeper than 5 cm has increased with time.

Keywords: Fukushima Daiichi Nuclear Power Plant accident , forest soil, Cs-137, scraper plate, tension-free lysimeter

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Change of sediment sources in suspended sediments due to surface decontamination in the Niida river catchment area affected by the Fukushima Daiichi nuclear power plant accident

*Yuichi Onda[1], Yuki Yamanaka[1], Yoshifumi Wakiyama[2], Keisuke Taniguchi[3], Takaaki Kubo[1]

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The Fukushima Daiichi Nuclear Power Plant (FDNPP) on March 2011 accident released massive amounts of radiocesium into the terrestrial environment such as Cs-137 and Cs-134. The Niida river basin (265 km ^{2}) on the north eastern part of Fukushima prefecture is indeed a case in point. The river basin has a highly contaminated area on its upstream part and evacuation have been ordered, and the cropland and paddy field becomes grassland in the summer of 2011, but the downstream part has not contaminated so much. The upstream area of the basin had been subject to decontamination works, such as scraping surface soil and reversal tillage and so on, since 2012.

In the Niida river basin, we installed an integrated suspended sediment sampler, turbidity sensor, and water level sensor at the downstream site starting in December 2012, and another three sites, Sakegawa-bashi (SK), Notegami-Kita (NT) and Warabi-daira (WR) in July 2014. The monitoring has been continued until now. During our monitoring period, most of the agricultural land (paddy and cropland), the topsoil up to 5 cm and replaced with lower part of the soil taken from 2014 to 2015.

We found that the flux of suspended sediments has increased with executing rate escalation of decontamination activity. Also after the decontamination activities, the number of counterclockwise hystereses increased compared with other types. In this presentation, we will discuss the effect of decontamination on the fine sediment yield to the downstream, and the use of radiocesium as a tracer of suspendiment sediment sources.

Keywords: Cs-137, suspended sediment, Niida river, Decontamination works

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Neasrshore transport of suspended radiocesium In the Fuksima Coast derived from Niida River induced by Typhoon Wipha

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The Fukushima Nuclear Power Plant (FNPP) accidentally leaked substantial amount of radiocesium to the environment in March 2011. The radiocesium is known to have three input pathways to the marine environment: atmospheric deposition,direct discharge from the FNPP, and river discharges. The last process has lagged behind the accident by occasional floods that have delivered terrestrial deposition through hydrological processes, while the other two processes occurred immediately after the accident. Therefore, the local coastal seas have suffered from continuous contamination due to riverine suspended radiocesium inputs that must be assessed carefully. Niida River,Fukushima,has been a source of riverine suspended radiocesium even after the FNPP accident, as its watershed was prominently covered with the atmospheric deposition at the accident.

In this study, we examined the oceanic dispersal and inventories of the sediments and suspended radiocesium deposited in the ocean floor derived from Niida River byusing a quadruple nested JCOPE2-ROMS 3D oceanic circulation model in a high-resolution configuration at the lateral grid spacing of 50 m.This model is coupled with a 3D multi-class sediment transport model along with a two-layer stratigraphy model of the marine bed,the iRIC-Nays 2DH river sediment transport model,the SWAN spectral wave model,and a static radiocesium absorption model. A particular attention was paid to the storm and subsequent flood event associated with Typhoon 201326 (Wipha)passed off the Fukushima Coast in October 2013,which provoked an enormous amount of precipitation,subsequent increase of the riverine freshwater discharge, and associated sediment and suspended radiocesium fluxes to the ocean. The model results were diagnosed with a guide of several in situ observed data collected in the Fukushima Coast after the storm. We found that the modeled and observed lateral and vertical distributions of sediment grain sizes and attached radiocesium concentrations were reasonably well correlated and consistent each other. We then investigated the accumulation and erosion of the sediments and resultant suspended radiocesium distribution around the river mouth and nearshore areas along the Fukushima Coast.

Keywords: suspended radiocesium, ROMS

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Particle size distribution and radiocesium concentration in suspended particles within the high turbidity layer at near sea bottom off Fukushima prefecture

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The Fukushima Dai-ichi Nuclear Power Plant accident of March 2011 resulted in the release of radiocesium to the ocean. The concentration of Fukushima-derived ^{137}Cs in pelagic fishes had been decreased drastically during two years from the accident, associated with the concentration of dissolved ^{137}Cs due to the dispersion and dilution of seawater. The concentration of ^{137}Cs in demersal fishes had also been decreasing for eight years, although the decreasing rates of them are slower than those of pelagic fishes. The seabed sediment in the coastal region of Fukushima revealed higher concentration of ^{137}Cs than those observed before the accident. To elucidate the fate of Fukushima-derived radiocesium in the oceanic environment, the benthic ecosystem in the coastal region of Fukushima is the most important study area.

In this study, we focused on the high turbidity layer observed at near sea bottom as a possible source of radiocesium for the benthic organisms in the coastal region of Fukushima. Field observation was conducted in the coastal region off Fukushima and nearby prefectures during June–July 2018. The LISST-200X was used for obtaining the vertical profiles of volumetric concentration of particles and particle size frequency at 28 stations. LISST-HOLO was used concurrently at some stations shallower than 200 m to obtain holographic image of particle. To measure the concentration of ^{137}Cs in suspended materials, large volume *in-situ* pump was deployed on the sea bottom for collecting suspended materials just above the sea bottom (ca. 80 cm above bottom) at three stations.
The volumetric concentration of particle (especially >100 μm) was increased with depth and formed a peak at pycnocline and was decreased with depth. From holography images, diatom colonies and crustacean plankton (copepod) frequently observed at this peak may represent the sub-surface chlorophyll peak was developed around pycnocline. The increase of volumetric concentration of particle were also observed at near sea bottom at some stations located around continental shelf (ca. 100–200 m depth). The particles of 10–100 μm were abundant at this high turbidity sea bottom boundary layer, on the other hands the particles within this size range were less abundant in the above water column. The holography images of particles represented variable forms including crustacean plankton (copepod), rod shape fragment and amorphous detritus at the high turbidity sea bottom boundary layer. The ^{137}Cs concentration of suspended particle collected at near sea bottom ranged from 0.1 to 0.2 Bq g-dry^{-1} and was 2 to 13 times higher than that in the sea bottom sediment at same location. These results (10–100 μm particles abundant in sea bottom boundary layer and relatively high ^{137}Cs concentration in this particles) revealed the high turbidity layer at near sea bottom could be one of the sources for radiocesium uptake by the benthic organisms. Further studies needed to verify the role of this suspended particles not only the variability of ^{137}Cs concentration, but also portion of organic fraction, particle size distribution, and the horizontal distribution of particles in the continental shelf area off Fukushima.

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Keywords: Fukushima Dai-ichi Nuclear Power Plant accident, Radiocesium, high turbidity layer, particle size distribution

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Fukushima-derived radiocesium in the subarctic region of the North Pacific Ocean in the summer of 2017

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The accident of Fukushima Dai-ichi Nuclear Power Plant occurred in March 2011 resulted in release of 20-40 PBq radiocesium into the environment. It is estimated that 70-80% of them deposited and discharged in the North Pacific Ocean and most of them are dissolved in seawater. Therefore, Fukushima-derived radiocesium has been spreading throughout the North Pacific along the surface water currents with dilution by seawater mixing. Previous studies revealed that radiocesium deposited and discharged in the coastal area of Japan was transported eastward along the surface current in the mid-latitude of the North Pacific Ocean and reached the west coast of the North American continent in 2015, about four years after the accident. We collected seawater samples during Japan Agency for Marine-Earth Science and Technology "Hakuho Maru" cruise conducted in the North Pacific in the summer of 2017 and measured activity concentrations of radiocesium in them. Because the activity concentration of Fukushima-derived ^{134}Cs has decreased to less than 1 Bq m^{-3} due to dilution and radioactive decay (its half-life is about 2 years), it is difficult to measure it unless it is concentrated. For the concentration, Cs resin (potassium nickel ferrocyanate on polyacrylnitrile, KNiFC-PAN) manufactured by Triskem was used. About 40 L of seawater sample was passed through 5 ml (about 1 g) of the Cs resin at a flow rate of 50 ml min^{-1} to concentrate the radiocesium in the resin. Stable cesium (^{133}Cs) chloride was added as a carrier to the seawater sample (concentration was about 100 ppb), and the recovery rate of radiocesium was estimated to be about 95% from a difference in ^{133}Cs concentration before and after the passing through the seawater sample. After washing the Cs resin in our laboratory on shore, activity concentrations of ^{134}Cs were measured using gamma ray spectrometers (Ge semiconductor detectors) in Japan Agency for Marine-Earth Science and Technology and Kanazawa University. According to vertical transection along with the two observation lines of east-west (47 north degree line) and north-south (145 west degree line) across the Gulf of Alaska in the eastern North Pacific, the activity concentration of Fukushima-derived ^{134}Cs in surface layer shallower than 300 m depth in the eastern and northern stations, namely stations closer to the coastal area of the North American continent was relatively high (the maximum decay-corrected concentration was 6 Bq m^{-3}). This suggests that Fukushima-derived ^{134}Cs reached the North American continent has been transported northward along the continent and then westward in high latitude (50-60 north degree) of the North Pacific. These results imply that Fukushima-derived ^{134}Cs will return to the coastal area of Japan along the anti-clockwise circulation in the subarctic area of the North Pacific (North Pacific subarctic gyre) within the next few years.

Keywords: Fukushima Dai-ichi Nuclear Power Plant accident, radiocesium, North Pacific

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Temporal and spatial variations of radiocaesium in the East China Sea and Sea of Japan until 2018

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The temporal and spatial variations of radiocaesium activity concentrations in the Sea of Japan (SOJ) and the East China Sea were investigated. We also investigated transport process from the North Pacific Ocean to the SOJ through the East China Sea (ECS) during 2012–2018. Since 2012, increase of Fukushima Dai-ichi Nuclear Power Plant derived ^{137}Cs activity concentrations were observed in the East China Sea (ECS) and Sea of Japan (SOJ) and reached maxima in 2014/2015 in the ECS and in 2015/2016 in the SOJ. In the ECS, the FNPP1-^{137}Cs activity concentrations tend to decrease after 2016. In 2017 and 2018, decreasing trend of FNPP1-^{137}Cs activity concentrations were also found in the SOJ. The propagation of Fukushima-derived radiocaesium in surface seawater from the ECS into the SOJ required approximately one year. The maximum FNPP1-^{137}Cs activity concentration at each monitoring station was 0.9-1.4 Bqm^{-3}, which contribute to about 40-49% increase against those to the ^{137}Cs activity concentration derived from the global fallout. It appeared that ^{134}Cs/^{137}Cs activity ratios indicated that part of the FNPP1-derived ^{137}Cs and ^{134}Cs was transported with 4-5 years-time scale to the ECS and then to the SOJ via Subtropical Mode Water from the North Pacific southern part of Japan (Inomata et al., 2018). In the ECS, clear meridional distribution of radiocaesium was observed in 2018. ^{137}Cs activity concentrations was low at Yonaguni and Ishigaki, south of ECS and high at west of Kyushu, north of ECS.

Keywords: Radiocaesium, Fukushima Dai-ichi Nuclear Power Plant accident, Sea of Japan, East China Sea

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[J] Poster | M (Multidisciplinary and Interdisciplinary)：M-AG Applied Geosciences

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_46

[M-AG41] Dynamics of radionuclides emitted from Fukuchima Dai-ichi Nuclear Power Plant in the environment

convener:Yoshio Takahashi(Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo), Kazuyuki Kita(Faculty of Science, Ibaraki University), Yuichi Onda(Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba), Daisuke Tsumune(Central Research Institute of Electric Power Industry)

The Great East Japan Earthquake caused the severe accident in TEPCO Fukushima dai-ichi nuclear power plant (FDNPP), leading to emission of huge amount of radionuclides to the environment. They have been transported and diffused by atmospheric motion, depositing them to soil and vegetation. Deposited radionuclides are dynamically shifted in the earth environment; atmosphere, soil, inland water, ocean, and ecosystem. To understand this dynamic shift in the environment and for the long-term prediction of the disaster by the radionuclides, investigation and discussion based on not only the earth sciences including ecology but also on the radiochemistry and other related sciences. In this session, various efforts to understand the dynamic behavior of radionuclides emitted from FDNPP accident in the earth system as well as to predict their influences on the environment. It is expected that this session will offer a good opportunity to discuss radionuclides in the earth environment from wide aspect and to exchange information in various research fields.

[MAG41-P01] Discovering U particle with Zr from CsMP emitted from Unit 1 of FDNPP using synchrotron radiation X-ray analyses

*Hikaru Miura[1], Yuichi Kurihara[2], Masayoshi Yamamoto[3], Aya Sakaguchi[4], Kazuya Tanaka[2], Shogo Higaki[5], Yoshio Takahashi[5] (1.Central Research Institute of Electric Power Industry, 2.JAEA, 3.University of Kanazawa, 4.University of Tsukuba, 5.The University of Tokyo)

[MAG41-P02] Atmospheric re-emission of radio-cesium with bioaerosols and trial for estimateing their emission flux

★Invited Papers

*Kazuyuki Kita[1], Naho Hayashi[1], Koutaro Minami[1], Mao Kimura[1], Yasuhito Igarashi[1,7], Kouji Adachi[2], Teruya Maki[3], Atsuyuki Sorimachi[4], Ishizuka Masahide[5], Jun Furukawa[6], Kazuhiko Ninomiya[8], Atsushi Shinohara[8], Olivier Masson[9] (1.Graduate School of Science and Engineering, Ibaraki University, 2.Meteorological Research Laboratory, 3.Kanazakwa University, 4.Fukushima Medical Univeristy, 5.Kagawa University, 6.Tsukuba University, 7.Kyoto University, 8.Osaka University, 9.IRSN)

[MAG41-P03] The effect of canopy interception processes on radiocesium and dissolved matter concentrations in throughfall

*Tomoki Shinozuka[1], Hiroaki Kato[2], Satoru Akaiwa[1], Yuichi Onda[2] (1.College of Geoscience, School of Life and Environmental Sciences, University of Tsukuba, 2.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba)

[MAG41-P04] Effects of RCs concentration and dissolved organic matter on RCs migration in soil under flowing condition

*Takahiro Tatsuno[1], Shoichiro Hamamoto[1], Naoto Nihei[1], Taku Nishimura[1] (1.Deptartment of Biological and Environmental Engineering, Graduate School of Agricultural and Life Sciences, University of Tokyo)

[MAG41-P05] Behavior of dissolved radiocesium in the decay degree of organic matter of deciduous broad-leaved trees

*Yoshito Sasaki[1], Tadafumi Niizato[1], Katsuaki Mitachi[2], Satomi Ito[1], Takayoshi Watanabe[1] (1.Japan Atomic Energy Agency , 2.ATOM TRANSPORT SERVICE CO., LTD)

[MAG41-P06] **Effect of Coarse Organic Matter on the Dissolved Radioactive Cesium Concentration in Stream Water from headwater catchment**

*Satoru Akaiwa[1], Hiroaki Kato[2], Tomoki Shinozuka[1], Yuichi Onda[2] (1.College of Geoscience, School of Life and Environmental Sciences, University of Tsukuba, 2.Center for Research on Isotopes and Environmental Dynamics, University of Tsukuba)

[MAG41-P07] **Eight-year monitoring study of radiocesium transfer in forest environments after the FDNPP accident**

*Hiroaki Kato[1], Yuichi Onda[1], Zul Hilmi Saidin[1], Momo Kurihara[1], Tomoki Shinozuka[2], Satoru Akaiwa[2] (1.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, 2.College of Geoscience, School of Life and Environmental Sciences, University of Tsukuba)

[MAG41-P08] Seasonal change of radiocaesium and its factor in the forest catchment contaminated by the Fukushima Dai-ichi Nuclear Power Station Accident

★Invited Papers

*Shota Kambayashi[1], Tatsuo Aono[1], Hiroki Hamajima[1], Hiroyuki Takahashi[1], Mitsuru Yamamura[2], Yutaka Yamada[1] (1.National Institute of Radiological Sciences, National Institutes for Quantum and Radiological Science and Technology, 2.Japan Conservation Engineers & Co.,LTD Inc.)

[MAG41-P09] Research of discharge radioactive Cs-bearing microparticles from a small forested catchment

*Satoshi Hadano[1], Shoichiro Hamamoto[1], Naoto Nihei[1], Taiga Okumura[1], Toshihiro Kogure[1], Taku Nishimura[1] (1.The University of Tokyo)

[MAG41-P10] Estimating impacts of direct release and riverine discharge on oceanic ^{137}Cs derived from the Fukushima Dai-ichi Nuclear Power Plant accident by an regional ocean model

★Invited Papers

*Daisuke Tsumune[1], Tsubono Takaki[1], Kazuhiro Misumi[1], Yutaka Tateda[1], Yuichi Onda[2], Michio Aoyama[3] (1.Central Research Institute of Electric Power Industry, 2.Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, 3.Institute of Environmental Radioactivity, Fukushima University)

[MAG41-P11] FNPP1 accident derived radiocaesium and tritium in Fukushima coast through the end of 2018

*Michio Aoyama[1], Yasunori Hamajima[2], Yayoi Inomata[2], Yuichiro Kumamoto[3], Tsubono Takaki[4], Daisuke Tsumune[4] (1.Institute of Environmnetal Radioactivity, Fukushima University, 2.Institute of Nature and Environmental Technology, Kanazawa university, 3.Japan Agency for Marine-Earth Science and Technology, 4.Environmental Science Research Laboratory, Central Research Institute of Electric Power Industry)

[MAG41-P12] Radiocesium in the swash zones off the coast of the Japan Sea

*Hyoe Takata[1], Mutsuo Inoue[2], Natsumi Kudo[1], Yuhei Shirotani[1] (1.Marine Ecoloy Research Institute, 2.Kanazawa Univ.)

[MAG41-P13] Numerical simulation of Cs-137 activity in the North Pacific using two atmospheric deposition fluxes estimated by atmospheric chemical transport models

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[MAG41-P14] Seasonal deposition of radiocesium in wooden houses from summer to winter seven years after the Fukushima nuclear accident

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Discovering U particle with Zr from CsMP emitted from Unit 1 of FDNPP using synchrotron radiation X-ray analyses

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Introduction: A large amount of radiocesium (Cs) was emitted into environment by the Fukushima Nuclear Power Plant (FDNPP) accident in March, 2011. Adachi et al. (2013) reported glassy water-insoluble microparticles including radiocesium, called as radiocesium-bearing microparticles (Type-A particles). Based on the $^{134}Cs/^{137}Cs$ ratio calculated by Nishihara et al. (2012), Type-A particle is thought to be emitted from Unit 2 or 3 of FDNPP (Higaki et al., 2017; Miura et al., 2018). Abe et al. (2014) detected uranium (U) in Type-A particle by synchrotron radiation measurement. In addition, Ochiai et al. (2018) reported that Type-A particle has UO_2 with zirconium (Zr). In contrast, Ono et al. (2017) reported new particles called as Type-B particles emitted from Unit 1. Type-B particle is different from Type-A particle in size, shape, Cs concentration and so on. We measured some Type-A and Type-B particles to clarify chemical condition of U by synchrotron radiation measurement. Difference in chemical condition of U in each particle may represent the difference of generating process or condition of each reactor unit at the accident.

Method: In this study, we collected Type-A and B particles from road dusts and non-woven fabric cloths from Fukushima by a wet separation method. After measurement of radioactivity with a high-purity germanium semiconductor detector, scanning electron microscope and energy dispersive X-ray spectroscopy analyses were performed to confirm that separated particles were Type-A or Type-B particles. X-ray fluorescence (XRF) mapping and X-ray adsorption near edge structure (XANES) measurement were performed at BL37XU (SPring-8, Hyogo). Bent Crystal Laue Analyzer (BCLA) was used to detect U peaks, because energy of U Lα emission is close to energies of rubidium Kα and strontium Kα emissions.

Results: We could detect U in Type-A and B particles using BCLA which decreased background contribution about one tenth. U-enriched area in the Type-B particle was about several microns, which is much bigger than U nano-particle in Type-A particle reported by Ochiai et al. (2018). This difference in size possibly suggested that U particle in Type-B particle was derived from melt in contrast to that in Type-A particle possibly produced from vapor. XANES measurement showed the presence of U(IV) in Type-B particle but also U(VI) in Type-A and B particles, which suggested $U(VI)O_2$ fuel was oxidized possibly due to its exposure to air at the surface of the particles. In the spots of detecting U, we also detected Zr which is used for fuel cladding tube. It is needed to identify chemical-states of Zr and U as a future study.

Keywords: FDNPP accident, Cesium-bearing microparticle, Synchrotron radiation X-ray analysis

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Atmospheric re-emission of radio-cesium with bioaerosols and trial for estimateing their emission flux

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Radionuclides emitted in the Fukushima dai-ichi nuclear power plant (FNDPP) accident in March 2011 have been deposited on the soil, ocean and vegetation. Re-suspension of radioactive cesium from the soil and vegetation to the atmosphere may be one of significant path in the diffusion of radionuclides after the accident.

We have measured the concentration of atmospheric Cs-134/137 radioactivity at Namie, Fukushima, where deposition amount of Cs-134/137 is relatively high. Atmospheric suspended particles have been collected on a sheet of quartz fiber filter with high-volume air samplers mounted at a playground site and forest site, and gamma-ray emission from them were measured with Ge detector to obtain the atmospheric activity concentration of Cs-134/137. A small part of each filter was used to measure chemical composition and microscope particle observation. To estimate emission flux, altitude difference of Cs activity concentration and bioaerosol concentration were measued using 6m height tower. By equiping ultrasonic anemometer, REA flux measurement of bioaerosols has been also tried.

The atmospheric Cs radioactivity concentration increased from late May to September, summer and autumn. It was higher in the forest than that at the playground in these season. The measured concentration of atmospheric Cs-134/137 was positively correlated with amount of carbonatious particles in these seasons. Bioaerosol sampling and analyses showed that major coarse particles in these seasons were spores of fungi and stain. We counted the spores collected on the sample filters to evaluate their number density, and found the number density was positively correlated with the atmospheric Cs radioactivity concentration. We collected fungi at Namie to sample its spores. About half of Cs-137 in the spores was removed by pure water, being consistent with similar experiment for the atmospheric particle samples. These results indicated that spore emission from fungi significantly contributes to the resuspension of radioactive Cs to the atmosphere in summer and autumn. Results of flux measurement will be shown.

Keywords: Radiocesium, atmospheric reemission, bioaerosol

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The effect of canopy interception processes on radiocesium and dissolved matter concentrations in throughfall

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This study examined the effects of canopy interception processes on the formation of throughfall and dissolved matter concentrations under the canopy. The concentrations of radiocesium and dissolved matter in throughfall were measured in the cedar forest stand located in Namie Town, Fukushima Prefecture. Furthermore, we investigated the influence of canopy structure on the generation of spatial heterogeneity in rainwater amount and dissolved matter concentrations in throughfall. The study period was about 4 months from June 25 to November 5, 2018. The results of this study indicated that the amount of thgoughfall increased with canopy openness. The Cs-137 concentration tended to decrease as the amount of throughfall increased, and consequently the transfer flux of Cs-137 from the canopy to the forest floor by the throughfall did not increase even if the throughfall increase. The particulate form of Cs-137 contained in the throughfall tended to decrease as the amount of throughfall increased. However, during large rainfall event such as typhoon, the proportion of the particulate Cs-137 increased regardless of throughfall amount. On the other hand, the dissolved Cs-137 and Mg^{2+}, Ca^{2+}, and K^{+} concentrations in throughfall decreased with the increase of canopy openness. These results suggested that rain properties and canopy structure affect the leaching flux of radiocesium from the canopy to rainwater. The periodical transfer flux of Cs-137 from the canopy to forest floor via throughfall was 0.25% of the initial atmospheric deposition (June 25 –September 13, 2018).

Keywords: radiocesium, canopy interception process, throughfall, monitoring

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Effects of RCs concentration and dissolved organic matter on RCs migration in soil under flowing condition

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INTRODUCTION

To understand migration of radiocesium (RCs) in soils is an important issue after the accident of Fukushima Dai-ichi nuclear power plant, Japan. In general, RCs strongly adsorb to soils, especially clay minerals in the soil. Frayed Edge Site (FES), siloxane ditrigonal cavity (SDC), and clay plane are known as RCs adsorption sites of clay minerals. The clay planes have much more adsorption sites than FES and SDC, while RCs adsorbed on the clay plane is relatively easy exchanged with other cations. On the other hand, RCs fixed on high affinity site such as SDC and FES cannot be readily exchanged with other cations. RCs concentration of the applied solution may affect effective sites for RCs adsorption. The lower RCs concentration in the soil solution, the greater the contribution of high affinity sites such as SDC and FES is expected.

Dissolved organic matters (DOMs) alter sorption and transport of RCs in soils. There are three possible processes in regard to DOM-induced RCs transport. First, DOMs in soil solution can complex with RCs and the RCs-DOM complexes enhance RCs transport to deeper layer or prevent it due to their adsorption to the soil. Second, DOMs in the soil solution may remove RCs adsorbed on the soils and promote RCs migration. Third, DOMs adsorbed on the soil can prevent RCs to access to high affinity sites (i e., FES and SDC).

There are many previous studies on the effects of RCs concentration and soil organic matters on RCs adsorption based on batch experiments with high DOM concentration. However, these studies are not enough for fully understanding RCs migration in a real soil system where water flow should occur and DOM concentration is low. In this study, we investigated the effect of DOM on the migration of RCs using two different concentrations of RCs solution by laboratory column experiments.

MATERIALS and METHODS

Soil sample was a weathered granite called as Masa-soil in local dialect. It was collected at an abandoned forest in Iitate, Fukushima, Japan. DOM solution was extracted from a litter which was collected from forest floor of university forest of the University of Tokyo in Chichibu city, Saitama prefecture, Japan in 2008. Dissolved organic carbon (DOC) in the DOM solution was adjusted to 20mg-C/L.

The Cs solutions with two different concentrations, 1.5×10^{-4} mol/L prepared by using stable CsCl (^{133}Cs) as the high one and 4.5×10^{-17} mol/L made by diluting the ^{137} Cs solution as low concentration solution. The Cs-DOM mixture was also used as a percolation solution.

An acrylic plastic column was used for the transport experiments. The soil column was prepared by packing air dried soil sample. Then, different solutions were applied with a constant ponding depth. Four different sequences of flowing solution were as follows ; (i) NaCl solution (pH6, ionic strength of 1mM) followed by Cs solution, (ii) NaCl solution followed by Cs-DOM mixed solution, (iii) DOM solution followed by Cs solution, and (iv) NaCl solution followed by Cs solution in soil which was adsorbed DOM in advance. Cs concentration of the effluent was measured. Some effluent solution was divided into water-soluble Cs and Cs-DOM complexes by ultrafiltration.

RESULTS and DISCUSSION

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During the experiment using the high concentration Cs solution, there was no significant difference in the effluent Cs concentration among all conditions ((i) - (iv)). On the other hand, when using the low Cs concentration solution, effluent Cs concentrations of the column (ii) and (iv) were higher than that of (i). The ultrafiltration for some selected effluent samples of the column experiment with Cs-DOM mixture as supplied solution, and effluents of (ii) and (iv) showed all the Cs in the effluents were water-soluble form. These findings suggest DOM did not work as a carrier for Cs, but rather promoted Cs migration by inhibiting Cs adsorption to high selective sites.

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Keywords: Fukushima, cesium, dissolved organic matter

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Behavior of dissolved radiocesium in the decay degree of organic matter of deciduous broad-leaved trees

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Approximately 70% of radiocesium released by the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Company Holdings accident was deposited in the forest and would remain in the forest. Dissolved radiocesium would be easy to be incorporated into organisms. There are many unknown parts regarding the elution mechanism of the elution of dissolved radiocesium from organic matter such as litter, which would be a potential source of dissolved radiocesium. Here we report the results of the study on the difference in transfer behavior of dissolved radiocesium at the different degree of decomposition of organic matter of deciduous broad-leaved tree leaves. After making organic matter with different degree of decomposition (litter, leaf mold, humus) using litter collected in deciduous broad - leaved forest in Fukushima prefecture, dissolution rates of dissolved radiocesium eluted from these organic matters were compared. The highest dissolution rate was litter in organic matters with different degrees of decomposition. The dissolution rate of leaf mold and humus was about 1/10 of that of litter. These results suggested that dissolved radiocesium elution from organic matter on the forest floor differs at the decomposition stage of organic matter

Keywords: Fukushima Dai-ichi Nuclear Power Plant accident, radiocesium, deciduous broad-leaved tree, litter layer

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Effect of Coarse Organic Matter on the Dissolved Radioactive Cesium Concentration in Stream Water from headwater catchment

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This study examined the mechanisms of radiocesium discharge via stream water in a headwater forest catchment. We measured the stream water runoff, the dissolved and particulate Cs-137 concentrations in spring water, stream water, soil water, suspended sediment and coarse organic matter in the forest catchment located in Namie Town of Fukushima Prefecture. We conducted sample collection for 6 times during the monitoring period from June 25 to September 13, 2018. Stream water was sampled at four locations, namely the spring water and the stream water in the experimental watershed, and the middle and the large scale catchments where the experimental watershed stream joins. The soil water was collected by using two types of zero tension lysimeter which consists of only litter layer, and the combination of litter and surface soil (0-10 cm) layers. Coarse organic matter was collected by a screen mesh installed in the downstream channel of the experimental watershed. The dissolved Cs-137 concentrations in stream water and soil water showed similar temporal changes with the increasing trend in July. In addition, the dissolved Cs-137concentration in stream water was higher than that of spring water, suggesting that the dissolved Cs-137 concentration in stream water increased during the stream water flowing down along the stream channel. In addition to the monitoring study in the experimental watershed, the sampling of stream water was conducted in total of 25 catchments located in Kawamata Town and Nihonmatsu City in Fukushima prefecture, on August 1, 2018. The dissolved Cs-137 concentration in each stream water sample was analyzed. The dissolved Cs-137 concentration in stream water increased with the proportion of forest area to the total catchment area, suggesting that the discharges of dissolved Cs-137 in stream water from forest area maintain the measured high Cs-137 concentrations in stream water.

Keywords: Fukushima Dai-ichi Nuclear Power Plant, dissolved cesium 137, stream water

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Eight-year monitoring study of radiocesium transfer in forest environments after the FDNPP accident

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This study investigated temporal changes in ^{137}Cs concentrations in environmental samples collected from various forests over 8 years following the accident, in Yamakiya district of Kawamata town. Cesium-137 was detected in all forest environmental samples; however, the concentration in most samples decreased exponentially with time. The decreasing trend of ^{137}Cs concentrations varied between needles/leaves and the outer bark of Japanese cedar and konara oak trees, suggesting that self-decontamination processes and internal recycling of ^{137}Cs varied among tree species and different tree parts. We selected a cedar stand in the highly contaminated area of Namie Town, the mechanisms of radiocesium leaching from forest canopy to rainwater and those influences to temporal trend of self-decontamination processes were examined by measuring particulate and dissolved radiocesium concentrations in throughfall.

Keywords: Fukushima Dai-ichi Nuclear Power Plant accident, Forest, Radiocesium

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Seasonal change of radiocaesium and its factor in the forest catchment contaminated by the Fukushima Dai-ichi Nuclear Power Station Accident

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A huge amount of radionuclides such as radiocaesium were dispersed and deposited on the territorial area of Fukushima Prefecture, Japan, after the accident at the TEPCO Fukushima Daiichi Nuclear Power Station (FDNPS) on March 2011. Since Fukushima prefecture is covered by about 70% of forest area, it is important to investigate the distribution, behavior and runoff process of radiocaesium in this area. In this study, we collected stream water from forest catchment and river water in mainstream within evacuation zone in vicinity of the FDNPS from December 2017 to February 2019 in order to assess the distribution, biogeochemical behavior and fluxes of dissolved radiocaesium in these areas. Regarding the analysis results and discussion, we reached the following findings.
1) Activity concentrations of dissolved ^{137}Cs collected in Takase River and Saruta River ranged from 10.3 to 37.2 mBq L^{-1}, 44.3 to 322.9 mBq L^{-1}, respectively. These results indicate that the activity concentration of dissolved radiocaesium (DRCs) is depended on the air does rate around catchment area in the river. Also, the DRCs collected in Takase River and upstream of Saruta River related to water temperature. This result suggests that the influential source of DRCs for these two rivers are due to desorption from litter.
2) Calculation results of dissolved ^{137}Cs (DCs-137) flux in Saruta River show that radiocaesium input form tributary streams have a great influence on DCs-137 flux of main stream. Moreover, DRCs activity concentration in pore water collected in reservoir was much higher than in overlying water, suggesting that a significant amount of radiocaesium in sediment desorb into pore water. The ^{137}Cs flux between the sediment and overlying water was comparable to fluxes from tributary streams. DCs-137 flux of Saruta River contribute to that of Takase River was also estimated to be about ten percent. This result indicates that dissolved radiocaesium input from forest catchment have a small influence on main river.

This work was supported by Research and Development to Radiological Sciences in Fukushima Prefecture.

Keywords: Radiocaesium, Behavior, Stream water, Forest catchment

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Research of discharge radioactive Cs-bearing microparticles from a small forested catchment

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INTRODUCTION

Vast amount of radioactive cesium (RCs) deposited by the accident of Fukushima Dai-Ichi Nuclear Power Plant (FDNPP). Fate of the RCs in the environments is important since RCs has long half-life. Previous studies estimated annual RCs runoff as about 0.1% or less of the total RCs deposition in the forest. Many previous studies reported concentration of suspended solids and RCs concentrations in water samples had linear correlation. However, there were still some extremely high RCs concentration was observed among water samples. Few studies analyzed such high RCs concentration water samples. Radioactive Cs-microparticles (CsMPs) are one of particulate RCs released from FDNPP. They are about 1-10 μm in size. The matrix is SiO2 glass which contains Cs and other elements such as iron, zinc and tin. One of the remarkable features of CsMPs is high radioactivity per volume compared with soil particles that absorb RCs. There is a possibility that a water sample showing high radioactivity may contain CsMPS. But few studies focused on CsMPs in suspended solids in river water from forested catchment. The aim of this study is to consider whether there is an outflow of CsMPs from forested catchment focusing CsPMs in suspended matter.

METHODS

Study site is a small forested catchment in Iitate village, Fukushima prefecture. Catchment area is around 56 ha. Estimated RCs deposition was 1 MBq m-2. Water level gauge, a turbidity meter, and automatic water sampler was installed for stream water monitoring and sampling. Water samples were brought to the laboratory and filtered to separate suspended matter and supernatant. RCs radioactivity of suspended matter, and Imaging Plate (IP) images were taken for suspended matter whose radioactivity was higher than the average. When expected microparticles which seemed to be CsMPs was detected on the IP image it was fractionated and isolated from suspended matter. Isolated particles were observed using a scanning transmission electron microscope (SEM, Hitachi S-4500) with an energy-dispersive X-ray detector (EDS, Kevex, SIGMA).

RESULTS

We isolated two CsMPs from all samples from stream water samples during summer of 2018. SEM image and gamma counter suggested small particles with a diameter of 2.4 μm emitted relatively high radioactivity. As a result of examining chemical composition of each CsMPs by EDS, such elements as silicon, zinc, and iron which were confirmed in previous research were confirmed. Also, they were isolated from the same sample, and RCs radioactivity of each CsMPs is 2.33 and 2.22 Bq which was about 12%

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against total RCs radioactivity of the water sample. On the other hand, approximately, the mass of the two CsMPs were 50 pg which was about 5.7×10^{-9} % against the total mass of the suspended matter in the water sample. It suggests that the contribution of CsMPs to RCs radioactivity of the water sample. From the view of suspended matter concentrations in the stream water sample, the sample from which we isolated CsMPs was collected at relatively frequent intensity rainfall and the out flow of CsMPs can be considered in the future.

AKNNOWLEDGEMENT

Authors would like to appreciate nonprofit organization Resurrection of Fukushima for their help to install water sampling facilities at Iitate village. This study was supported by Grants-in-Aid for Scientific Research (15H02467). SEM work was conducted at Advanced Characterization Nanotechnology Platform of the University of Tokyo, supported by "Nanotechnology Platform" of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan.

Keywords: Fukushima, radioactive Cs-bearing microparticles, stream water monitoring and sampling

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Estimating impacts of direct release and riverine discharge on oceanic ^{137}Cs derived from the Fukushima Dai-ichi Nuclear Power Plant accident by an regional ocean model

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A series of accidents at the Fukushima Dai-ichi Nuclear Power Plant (1F NPP) following the Great East Japan Earthquake and tsunami of 11 March 2011 resulted in the release of radioactive materials to the ocean. Measured ^{137}Cs activities in the coastal zone adjacent to the 1F NPP are still higher than the one before the accident because sources to the ocean are still existing. The Regional Ocean Model System (ROMS) was employed for regional-scale simulation of ^{137}Cs activity in the ocean offshore of Fukushima, the sources of radioactivity being direct release, atmospheric deposition, the inflow of ^{137}Cs deposited into the ocean by atmospheric deposition outside the domain of the model, and river discharges. Direct release of ^{137}Cs was estimated for 7 years after the accident by comparing simulated results and measured activities adjacent to the accident site. In addition, riverine discharge rates ^{137}Cs were also estimated by multiplication between river flow simulation rate and measured ^{137}Cs activities. Simulated atmospheric deposition to the ocean was employed by atmospheric transport model. Inflow of ^{137}Cs from boundary sections was set by the results of the North Pacific scale ocean model. Sensitivity experiments were carried out to investigate the contributions of each source to measured ^{137}Cs activities in the ocean. We focused on the term from 2013 to 2016 because there were few data in the river before 2012, and also focused on dissolved ^{137}Cs because most of ^{137}Cs is dissolved form in the ocean.

Simulated ^{137}Cs activity attributable to direct release were in good agreement with measured data in the coast zone adjacent to the 1F NPP, because the effect of direct release was dominant from 2013 to 2016. On the other hands, simulated results attributable to inflow from boundary sections were slightly underestimated to the measured data offshore area. This suggests that recirculation of subducted ^{137}Cs to the surface layer was underestimated in the North Pacific model. Apparent half-life of direct released and river discharged ^{137}Cs activity were estimated to be about 1 year and 2 years, respectively. And apparent half-life of inflow of ^{137}Cs activity was much longer due to time scale of dilution process in the North Pacific. Apparent half-life of each source should be similar to the measured one attributable to each source. Apparent half-life of measured ^{137}Cs activity adjacent to the 1F NPP was about 1 year, on the other hand, the ones increased with increasing distance from the 1F NPP. Apparent half-life of measured data was about 2 years in front of the Uda river mouth where is far from the 1F NPP. Although ^{137}Cs activity in this area was mainly affected by the river input, simulated ^{137}Cs activities with river input were one fifth of observations. There is a brackish lagoon, Matsukawa-ura in front of Uda river mouth. The observed ^{137}Cs activities in the Matsukawa-ura were 3-5 times larger than the one in the Uda river. This suggests the removal process from particle ^{137}Cs to dissolved form in the brackish lagoon may be important.

Keywords: Fukushima Dai-ichi Nuclear Power Plant accident, Cs-137, Regional Ocean Model, Direct release, River input

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FNPP1 accident derived radiocaesium and tritium in Fukushima coast through the end of 2018

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The temporal variation of 137Cs activity concentration are similar and 137Cs activity concentration was low in winter (January - February) and high in summer-fall (July - October) both at the inside the port and 56N canal of Fukushima Dai-ichi nuclear power plant (FNPP1). 137Cs at both stations might be originated from the same source. The concentration in the port drops about one order of magnitude lower when the installation of the sea side barrier wall in 2015, while 137Cs activity concentration at 56 N canal did not follow a trend in the port, so the leakage route to the port and 56N canal may be different. After 2016, 137Cs activity concentration at 56N canal did not change very much and annual average of 137Cs activity concentration was 100-140 Bq m-3 in 2016, 2017 and 2018. At Tomioka (10 km to the south from FNPP1), 137Cs activity concentration was about 1/10 of the 137Cs activity concentration at 56N canal and showed the same tendency. At Soma (48 km to the north from FNPP1), 137Cs activity concentration was about half of those at Tomioka in general. 137Cs activity concentration was 34 Bq m-3 at Tomioka River in June 2018 while 137Cs activity concentration in seawater was 11 Bq m-3 in June 2018.
3H activity concentration in Tomioka River decreased from ca. 1000 Bq m-3 in 2013 to ca. 400 Bq m-3 in 2018. 3H activity concentration in seawater collected at Tomioka did not change and ranged from 90 to 160 Bq m-3 during the period from 2014 to 2018. Good linear relationship between 137Cs and 3H in 2014 indicates that the source of both radionuclides should be liquid form and originated from same place.

Keywords: radiocaesium, tritium, Fukuhsima accident, fukushima coast

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Radiocesium in the swash zones off the coast of the Japan Sea

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Radiocesium concentrations were measured in seawater and sediment samples collected in the swash zones in Ishikawa and Niigata prefectures, off the coast of Japan Sea opposite to the side where TEPCO Fukushima daiichi Nuclear Power Plant (FDNPP) is located in September 2016 and August 2017, five to six years after the accident. Cs-134 in the seawater samples was detected, suggesting the intrusion of FDNPP-derived radiocesium in both swash zones. FDNPP-derived radiocesium was appeared to be transported by the Tsushima Warm Current. In the surface sediments only ^{137}Cs was detected during the sampling period. We could not find out the presence of the FDNPP-derived radiocesium in the corresponding sediment on the swash zones; however, detected radiocesium in those sediments was assumed to be influenced by ^{137}Cs of FDNPP-derived radiocesium little for Ishikawa area and some for Niigata area.

Keywords: Japan Sea, Cs-134

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Numerical simulation of Cs-137 activity in the North Pacific using two atmospheric deposition fluxes estimated by atmospheric chemical transport models

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We investigated the difference in the ^{137}Cs activity in the North Pacific Ocean (NPO) water after the Fukushima Dai-ichi Nuclear Power Plant (1F NPP) accident using two atmospheric deposition fluxes estimated by atmospheric chemical transport models; Model of Aerosol Species IN the Global Atmosphere (: MASINGAR MK-II) (Aoyama et al, 2015) and Meteorological Research Institute Passive-tracers Model for radionuclides (MRI-PM/r) (Kajino et al, 2012). The difference between both models is the total deposition amount into the NPO water in March and April 2011; 6.4 PBq for MASINGAR, 5.0 PBq for MPI-PM/r. In addition, The MASINGAR estimated larger (smaller) total deposition in north (south) of Kuroshio Extension than MPI-PM/r.
We conducted two five-ensemble simulations of ^{137}Cs activity in the North Pacific Ocean (NPO) from 2011 to 2020 due to the direct discharge (Tsumune et al., 2013) from the power plant and the atmospheric deposition flux by using the Regional Ocean Model System (ROMS) with variable mesh of 1/12º-1/4º in horizontal.
Since the calculated ^{134}Cs using the original atmospheric deposition fluxes showed smaller than the observations in the surface water in almost whole NPO from 2011 to 2014, we calculated the magnifications for the fluxes by the regression analysis between the observed and calculated ^{134}Cs. The magnifications provided the increase in the total amounts of ^{134}Cs and ^{137}Cs activity in NPO water after the accident, which is 16±1.5 PBq for MASINGAR, 21±2 PBq for MPI-PM/r. The Comparison between the observations and the ^{137}Cs calculated with the magnified fluxes represented that the correlation coefficient and the root mean square error are 0.86 and 5.7 Bq/ m^{-3} for MASINGAR, 0.75 and 7.3 Bq/ m^{-3} for MPI-PM/r.
The vertical distributions of the ^{137}Cs for the model with MPI-PM/r flux represented relatively larger in the Subtropical Mode Water in 165 ºE in 2012 than that for the model with MASINGAR flux. The model with MPI-PM/r flux consequentially represented that the^{137}Cs activity was able to be detected west of Okinawa Islands until 2014, while MASINGAR until 2012.

Keywords: Cs-137, North Pacific ocean, atmospheric deposition fluxes

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Seasonal deposition of radiocesium in wooden houses from summer to winter seven years after the Fukushima nuclear accident

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As the evacuation zone covering around the Fukushima nuclear plant will be re-opened, some of residents would return to their houses. Nevertheless reports on the contamination in their houses are limited [1], especially the information of short-time scale contamination is completely insufficient. Due to the diversity of residents' lifestyles, to provide information of deposition interior the house is very important from the perspective of radiation protection prior to cancellation of the evacuation order.

In this study, seasonal deposition of radiocesium contamination interior the wooden houses in the evacuation zone, Fukushima, Japan, has been investigated from Sep. 2018 to Feb. 2019.

Because electric power has been interrupted since the Fukushima accident in 2011, dust sampler could not use for sampling over research period. Thus, a method of collecting radiocesium using cloths was applied. Although this method is capable of long-term sampling, it is not as efficient as the method using basin. Therefore, the results of this research may be underestimated than the actual deposition.

Two representative results are shown below:

[A case in Okuma town] The house to be surveyed is located about 5 km from the Fukushima nuclear plant and was a wooden house built in 2007. In this house, deposition has been confirmed to range from 3.2e-4 to 4.1e-5 $Bq \cdot cm^{-2} \cdot day^{-1}$ from summer to winter season, 2018 and it was found that this range was one order of magnitude less than the outside deposition of the same period. During the survey period, there was a positive correlation between the number of days with no precipitation and the amount of deposition.

[A case in Namie town] One of the houses in Namie Town is located about 11 km away from the Fukushima nuclear plant and was a typical Japanese-style house. From the end of August to the beginning of September, deposition was higher than that in other seasons, which was 4.0e-4 $Bq \cdot cm^{-2} \cdot day^{-1}$. This may be caused by frequent entry of residents for the care of the house.

[1] N. Shinohara and H. Yoshida-Ohuchi, Radiocesium contamination in house dust within evacuation areas close to the Fukushima Daiichi nuclear power plant, Environment international, 114, 107-114, 2018.

Keywords: Fukushima nuclear accident, house dust, radiocesium, lifestyle

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[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-SD Space Development & Earth Observation from Space

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_8

[M-SD42] A new era of international space collaboration using microsatellites

convener:Junichi Kurihara(Graduate School of Science, Hokkaido University), Joel Joseph Jr Marciano(Advanced Science and Technology Institute, Department of Science and Technology, Philippines), Huy Xuan Le(Vietnam National Space Center)

Microsatellites have great potential as remote sensing platforms, because of the cost-effective implementation of satellite constellations, which increase their overall temporal resolution and ground coverage for Earth observation. However, it is difficult for one single university or institution to maintain a satellite constellation composed of many microsatellites. Recently, the Asian Microsatellite Consortium (AMC) comprising 16 space agencies and universities from nine Asian nations has been created to develop microsatellite technologies and use collected data relating to the environment and natural disasters, etc. This international framework is the first step to share remote sensing data from the microsatellites by the members of the consortium, instead of making a satellite constellation by a single owner. The microsatellites such as the DIWATA-2 (Philippines), MicroDragon (Vietnam), and RISESAT (Japan) developed by the AMC members will be launched in the last quarter of 2018. This session is a unique opportunity to discuss microsatellite development and utilization in terms of international collaboration and data sharing. This session welcomes presentations on microsatellite remote sensing including satellite development and operation, sensor development and calibration, data analysis and utilization. We also seek presentations on ground and information systems, international collaborations, and educational programs using microsatellites.

[MSD42-P01] A high spatial resolution multispectral remote sensing by the RISESAT microsatellite

*Junichi Kurihara[1], Toshinori Kuwahara[2], Shinya Fujita[2], Yuji Sakamoto[2], Yukihiro Takahashi[1] (1.Graduate School of Science, Hokkaido University, 2.Graduate School of Engineering)

[MSD42-P02] Initial check out and experiment plan of Very Small Optical Transmitter (VSOTA) on board a micro satellite RISESAT for Space-Ground Optical Communication

*Hiroo Kunimori[1], Hideki Takenaka[1], Toshinori Kuwahara[2], Yuji Sakamoto[2], Shinya Fujita[2], Hannah Tomio[2], MOROKOT SAKAL[2], Junichi Kurihara[3] (1.National Institute of Information and Communications Technology, 2.Tohoku Univ., 3.Hokkaido Univ.)

[MSD42-P03] Ten years history of Tohoku University ground station and operation system for micro and nano satellites

*Yuji Sakamoto[1], Toshinori Kuwahara[1], Shinya Fujita[1] (1.Tohoku University)

[MSD42-P04] Development of Thermal Infrared Sensor Camera on board LAPAN-A4 for Thunderstorm Cloud Observation

*Purwadi Purwadi[1,2], Yukihiro Takahashi[1], Junichi Kurihara[1], M. Arif Saifudin[3] (1.Department of Cosmosciences, Hokkaido University, Sapporo 0600810, Japan, 2.Agency for Assessment and Application of Technology (BPPT), Jakarta 10340, Indonesia, 3.Indonesian National Institute of Aeronautics and Space (LAPAN), Jawa Barat, 16310, Indonesia)

A high spatial resolution multispectral remote sensing by the RISESAT microsatellite

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Microsatellites for Earth observation have been developed jointly by Hokkaido and Tohoku Universities in Japan. The High-Precision Telescope (HPT), which is a high (3-5 m) spatial resolution multispectral sensor, was developed by Hokkaido University. The HPT has been installed on the RISING-2 (launched in 2014), DIWATA-1 (2016), and DIWATA-2 (2018) microsatellites developed mainly by Tohoku University. However, the HPT installed on the RISESAT microsatellite using the liquid crystal tunable filter (LCTF) technology for wavelength scanning in the visible (420–700 nm) and the near-infrared region (650–1050 nm) is the greatest in terms of number of spectral bands. The advantages offered by the LCTF technology are reductions in the size, weight, and power consumption of the sensor, the flexibility of the spectral bands and data volume, and compatibility with off-nadir pointing. The central wavelength of the spectral bands is electrically tunable for every image acquisition; hence, the data volume could be reduced by choosing appropriate spectral bands for specific purposes. This flexibility allows a single multispectral sensor on a nano/microsatellite to be applied to various remote sensing fields, making it comparable with hyperspectral sensors.

The RISESAT microsatellite was successfully launched by the Epsilon-4 launch vehicle on 18 January 2019 from Uchinoura Space Center, Kagoshima, Japan. The satellite was injected into a Sun-synchronous, low Earth orbit at about 500 km. In this paper, we present preliminary results of multispectral imaging by the HPT and review its performance evaluation. We also discuss the scientific collaboration with other microsatellites and the possible contribution to the Asian Microsatellite Consortium.

Keywords: Earth observation, microsatellite, multispectral sensor, remote sensing

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Initial check out and experiment plan of Very Small Optical Transmitter (VSOTA) on board a micro satellite RISESAT for Space-Ground Optical Communication

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A 1 kg class optical transmitter on board a 50 kg class satellite Rapid International Scientific Experiment Satellite (RISESAT) launched by Epsilon rocket #4 in January 18, 2019. The transmitter named Very Small Optical Transmitter (VSOTA) has heritage from NICT space optical communication development over 2 decades and most recently the Small Optical Transponder (SOTA) equipped on board a micro satellite SOCRATES which NICT conducted demonstration from 2014 to 2016 between satellite and optical ground station in Japan and international partners.
VSOTA has 2 wavelengths laser diodes for optical downlink with no gimbal tracking function. The communication speed can be selected in the range from 10 kbps to a 6 Mbps. A retro reflector is located to assist satellite pointing and orbit prediction as well.
It is the most compact and lightweight optical communication device onboard for satellite developed in Japan so far. It narrowed down its function to the simplest form to adapt limited resource on satellite in size, weight and power consumption, aiming to expand its downlink capability for micro sat at the same time with lower cost. The goal of the mission is to acquire optical communication technology in micro satellites to apply an on-demand type remote sensing with featuring the high attitude control system such as target pointing needed as well for the optical communication to target ground station.
The orientation to the ground is based on satellite attitude control. It has a function of performing the guide beam for laser ranging from the ground using a camera for science such as High Precision Telescope (HPT) on board.
On January 21 and February 13, we confirmed that the electrical parts including Laser Diode (LD) was turned on and it operated normally by checking telemetry of power and temperature sensors built in LD circuit board.
We describe the features of communication and ranging experiment plan and initial check out result for the satellite as well as for the ground station.

Keywords: Micro satellite, Optical Space Communication, Satellite Laser Ranging

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Ten years history of Tohoku University ground station and operation system for micro and nano satellites

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1. Tohoku University

Tohoku University and collaboration companies have developed three satellites, DIWATA-2, RISESAT, and ALE-1, which were launched on Oct. 2018 and Jan. 2019. The ground station with 2.4-m diameter parabola dish and U/S/X band antennas is being managed in the university, and three satellites are now being operated every day. In this presentation, the hardware and software system included in this ground station are described, which were being maintained and extended since 2009. Also, ground station network with our collaboration universities and companies are introduced, which are located in Philippines, Sweden, Hakodate and Fukui.

Ground station in Tohoku University, called CRESST, was refurbished for our 1st satellite SPRITE-SAT in 2009. In these 10 years, the station used for total 6 microsatellites and 4 cubesats. Low earth orbit satellites are flying over the station for 9 to 12 minutes per opportunity, and the antennas and transceiver frequencies are controlled by calculating the satellite orbits. By only setting the target satellite names, the station is automatically woken up, controlled properly, and suspended again. Operations are not necessary to manage the antennas, and can concentrate on the communication with satellites.

Currently, more 3 satellites, DIWATA-1, RISING-2, and SPRITE-SAT are also tracked and communicated as well as latest 3 satellites. The satellites compatible to this station are registered as JCUBE-B group satellites in International Telecommunication Union. Several satellite are planned to use this station in a few years. The register to ITU will spend the time more than 1 year, and this can make a trouble in project schedule. A satellite can be completed in 1 to 1.5 years in short-term project, and radio license can be a matter. By using this station and compatible radio specifications, it will promote a new satellite project and expand the collaborative partners.

Keywords: microsatellite, satellite operation, ground station

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Development of Thermal Infrared Sensor Camera on board LAPAN-A4 for Thunderstorm Cloud Observation

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Thunderstorm cloud, which growth vertically, has potential disaster risk like heavy rainfall, hail, micro-burst, and lightning. Cloud top altitude, volume, and growth speeds of thunderstorm cloud could be the parameter to predict its potential hazard. In this session, we will show our methodology to observe thunderstorm cloud using thermal infrared sensors camera which will be installed in the LAPAN-A4. This micro-satellite will be launched in 2020 FSY in the altitude ~ 500 kilometer with sun-synchronous polar orbit and inclination 97°. So, thermal infrared sensor camera will provide a temperature distribution with a resolution of ~ 180 meters and a field of view of ~ 56.3 x 42.2 kilometers. Using this high resolution thermal infrared sensor camera, the cloud top altitude can be estimated, assuming a temperature profile of the ambient atmosphere. By making such observation at some time interval, the developing speed of the thunderstorm cloud can be calculated in 3D.

Acknowledgement: This work was supported by Japan Society for the Promotion of Science (JSPS), Core-to-Core Program, B. Asia-Africa Science Platforms, by Japan Science and Technology Agency(JST) together with Technology and Higher Education(RISTEKDIKTI) of the of Indonesia under the e-ASIA Joint Research Program, and by Japan International Cooperation Agency (JICA) and JST, SATREPS.

Keywords: Thunderstorm cloud, thermal infrared sensor camera, LAPAN-A4

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[E] Poster | M (Multidisciplinary and Interdisciplinary)：M-SD Space Development & Earth Observation from Space

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_47

[M-SD42] A new era of international space collaboration using microsatellites

convener:Junichi Kurihara(Graduate School of Science, Hokkaido University), Joel Joseph Jr Marciano(Advanced Science and Technology Institute, Department of Science and Technology, Philippines), Huy Xuan Le(Vietnam National Space Center)

Microsatellites have great potential as remote sensing platforms, because of the cost-effective implementation of satellite constellations, which increase their overall temporal resolution and ground coverage for Earth observation. However, it is difficult for one single university or institution to maintain a satellite constellation composed of many microsatellites. Recently, the Asian Microsatellite Consortium (AMC) comprising 16 space agencies and universities from nine Asian nations has been created to develop microsatellite technologies and use collected data relating to the environment and natural disasters, etc. This international framework is the first step to share remote sensing data from the microsatellites by the members of the consortium, instead of making a satellite constellation by a single owner. The microsatellites such as the DIWATA-2 (Philippines), MicroDragon (Vietnam), and RISESAT (Japan) developed by the AMC members will be launched in the last quarter of 2018. This session is a unique opportunity to discuss microsatellite development and utilization in terms of international collaboration and data sharing. This session welcomes presentations on microsatellite remote sensing including satellite development and operation, sensor development and calibration, data analysis and utilization. We also seek presentations on ground and information systems, international collaborations, and educational programs using microsatellites.

[MSD42-P01] A high spatial resolution multispectral remote sensing by the RISESAT microsatellite

*Junichi Kurihara[1], Toshinori Kuwahara[2], Shinya Fujita[2], Yuji Sakamoto[2], Yukihiro Takahashi[1] (1.Graduate School of Science, Hokkaido University, 2.Graduate School of Engineering)

[MSD42-P02] Initial check out and experiment plan of Very Small Optical Transmitter (VSOTA) on board a micro satellite RISESAT for Space-Ground Optical Communication

*Hiroo Kunimori[1], Hideki Takenaka[1], Toshinori Kuwahara[2], Yuji Sakamoto[2], Shinya Fujita[2], Hannah Tomio[2], MOROKOT SAKAL[2], Junichi Kurihara[3] (1.National Institute of Information and Communications Technology, 2.Tohoku Univ., 3.Hokkaido Univ.)

[MSD42-P03] Ten years history of Tohoku University ground station and operation system for micro and nano satellites

*Yuji Sakamoto[1], Toshinori Kuwahara[1], Shinya Fujita[1] (1.Tohoku University)

[MSD42-P04] Development of Thermal Infrared Sensor Camera on board LAPAN-A4 for Thunderstorm Cloud Observation

*Purwadi Purwadi[1,2], Yukihiro Takahashi[1], Junichi Kurihara[1], M. Arif Saifudin[3] (1.Department of Cosmosciences, Hokkaido University, Sapporo 0600810, Japan, 2.Agency for Assessment and Application of Technology (BPPT), Jakarta 10340, Indonesia, 3.Indonesian National Institute of Aeronautics and Space (LAPAN), Jawa Barat, 16310, Indonesia)

A high spatial resolution multispectral remote sensing by the RISESAT microsatellite

*Junichi Kurihara[1], Toshinori Kuwahara[2], Shinya Fujita[2], Yuji Sakamoto[2], Yukihiro Takahashi[1]

1. Graduate School of Science, Hokkaido University, 2. Graduate School of Engineering

Microsatellites for Earth observation have been developed jointly by Hokkaido and Tohoku Universities in Japan. The High-Precision Telescope (HPT), which is a high (3-5 m) spatial resolution multispectral sensor, was developed by Hokkaido University. The HPT has been installed on the RISING-2 (launched in 2014), DIWATA-1 (2016), and DIWATA-2 (2018) microsatellites developed mainly by Tohoku University. However, the HPT installed on the RISESAT microsatellite using the liquid crystal tunable filter (LCTF) technology for wavelength scanning in the visible (420–700 nm) and the near-infrared region (650–1050 nm) is the greatest in terms of number of spectral bands. The advantages offered by the LCTF technology are reductions in the size, weight, and power consumption of the sensor, the flexibility of the spectral bands and data volume, and compatibility with off-nadir pointing. The central wavelength of the spectral bands is electrically tunable for every image acquisition; hence, the data volume could be reduced by choosing appropriate spectral bands for specific purposes. This flexibility allows a single multispectral sensor on a nano/microsatellite to be applied to various remote sensing fields, making it comparable with hyperspectral sensors.

The RISESAT microsatellite was successfully launched by the Epsilon-4 launch vehicle on 18 January 2019 from Uchinoura Space Center, Kagoshima, Japan. The satellite was injected into a Sun-synchronous, low Earth orbit at about 500 km. In this paper, we present preliminary results of multispectral imaging by the HPT and review its performance evaluation. We also discuss the scientific collaboration with other microsatellites and the possible contribution to the Asian Microsatellite Consortium.

Keywords: Earth observation, microsatellite, multispectral sensor, remote sensing

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Initial check out and experiment plan of Very Small Optical Transmitter (VSOTA) on board a micro satellite RISESAT for Space-Ground Optical Communication

*Hiroo Kunimori[1], Hideki Takenaka[1], Toshinori Kuwahara[2], Yuji Sakamoto[2], Shinya Fujita[2], Hannah Tomio[2], MOROKOT SAKAL[2], Junichi Kurihara[3]

1. National Institute of Information and Communications Technology, 2. Tohoku Univ., 3. Hokkaido Univ.

A 1 kg class optical transmitter on board a 50 kg class satellite Rapid International Scientific Experiment Satellite (RISESAT) launched by Epsilon rocket #4 in January 18, 2019. The transmitter named Very Small Optical Transmitter (VSOTA) has heritage from NICT space optical communication development over 2 decades and most recently the Small Optical Transponder (SOTA) equipped on board a micro satellite SOCRATES which NICT conducted demonstration from 2014 to 2016 between satellite and optical ground station in Japan and international partners.
VSOTA has 2 wavelengths laser diodes for optical downlink with no gimbal tracking function. The communication speed can be selected in the range from 10 kbps to a 6 Mbps. A retro reflector is located to assist satellite pointing and orbit prediction as well.
It is the most compact and lightweight optical communication device onboard for satellite developed in Japan so far. It narrowed down its function to the simplest form to adapt limited resource on satellite in size, weight and power consumption, aiming to expand its downlink capability for micro sat at the same time with lower cost. The goal of the mission is to acquire optical communication technology in micro satellites to apply an on-demand type remote sensing with featuring the high attitude control system such as target pointing needed as well for the optical communication to target ground station.
The orientation to the ground is based on satellite attitude control. It has a function of performing the guide beam for laser ranging from the ground using a camera for science such as High Precision Telescope (HPT) on board.
On January 21 and February 13, we confirmed that the electrical parts including Laser Diode (LD) was turned on and it operated normally by checking telemetry of power and temperature sensors built in LD circuit board.
We describe the features of communication and ranging experiment plan and initial check out result for the satellite as well as for the ground station.

Keywords: Micro satellite, Optical Space Communication, Satellite Laser Ranging

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Ten years history of Tohoku University ground station and operation system for micro and nano satellites

*Yuji Sakamoto[1], Toshinori Kuwahara[1], Shinya Fujita[1]

1. Tohoku University

Tohoku University and collaboration companies have developed three satellites, DIWATA-2, RISESAT, and ALE-1, which were launched on Oct. 2018 and Jan. 2019. The ground station with 2.4-m diameter parabola dish and U/S/X band antennas is being managed in the university, and three satellites are now being operated every day. In this presentation, the hardware and software system included in this ground station are described, which were being maintained and extended since 2009. Also, ground station network with our collaboration universities and companies are introduced, which are located in Philippines, Sweden, Hakodate and Fukui.

Ground station in Tohoku University, called CRESST, was refurbished for our 1st satellite SPRITE-SAT in 2009. In these 10 years, the station used for total 6 microsatellites and 4 cubesats. Low earth orbit satellites are flying over the station for 9 to 12 minutes per opportunity, and the antennas and transceiver frequencies are controlled by calculating the satellite orbits. By only setting the target satellite names, the station is automatically woken up, controlled properly, and suspended again. Operations are not necessary to manage the antennas, and can concentrate on the communication with satellites.

Currently, more 3 satellites, DIWATA-1, RISING-2, and SPRITE-SAT are also tracked and communicated as well as latest 3 satellites. The satellites compatible to this station are registered as JCUBE-B group satellites in International Telecommunication Union. Several satellite are planned to use this station in a few years. The register to ITU will spend the time more than 1 year, and this can make a trouble in project schedule. A satellite can be completed in 1 to 1.5 years in short-term project, and radio license can be a matter. By using this station and compatible radio specifications, it will promote a new satellite project and expand the collaborative partners.

Keywords: microsatellite, satellite operation, ground station

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Development of Thermal Infrared Sensor Camera on board LAPAN-A4 for Thunderstorm Cloud Observation

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1. Department of Cosmosciences, Hokkaido University, Sapporo 0600810, Japan, 2. Agency for Assessment and Application of Technology (BPPT), Jakarta 10340, Indonesia, 3. Indonesian National Institute of Aeronautics and Space (LAPAN), Jawa Barat, 16310, Indonesia

Thunderstorm cloud, which growth vertically, has potential disaster risk like heavy rainfall, hail, micro-burst, and lightning. Cloud top altitude, volume, and growth speeds of thunderstorm cloud could be the parameter to predict its potential hazard. In this session, we will show our methodology to observe thunderstorm cloud using thermal infrared sensors camera which will be installed in the LAPAN-A4. This micro-satellite will be launched in 2020 FSY in the altitude ~ 500 kilometer with sun-synchronous polar orbit and inclination 97°. So, thermal infrared sensor camera will provide a temperature distribution with a resolution of ~ 180 meters and a field of view of ~ 56.3 x 42.2 kilometers. Using this high resolution thermal infrared sensor camera, the cloud top altitude can be estimated, assuming a temperature profile of the ambient atmosphere. By making such observation at some time interval, the developing speed of the thunderstorm cloud can be calculated in 3D.

Acknowledgement: This work was supported by Japan Society for the Promotion of Science (JSPS), Core-to-Core Program, B. Asia-Africa Science Platforms, by Japan Science and Technology Agency(JST) together with Technology and Higher Education(RISTEKDIKTI) of the of Indonesia under the e-ASIA Joint Research Program, and by Japan International Cooperation Agency (JICA) and JST, SATREPS.

Keywords: Thunderstorm cloud, thermal infrared sensor camera, LAPAN-A4

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[E] Oral | M (Multidisciplinary and Interdisciplinary)：M-SD Space Development & Earth Observation from Space

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | A01 TOKYO BAY MAKUHARI HALL

[M-SD42] A new era of international space collaboration using microsatellites

convener:Junichi Kurihara(Graduate School of Science, Hokkaido University), Joel Joseph Jr Marciano(Advanced Science and Technology Institute, Department of Science and Technology, Philippines), Huy Xuan Le(Vietnam National Space Center), Chairperson:Junichi Kurihara(Hokkaido University), Tetsuro Ishida(Hokkaido University)

Microsatellites have great potential as remote sensing platforms, because of the cost-effective implementation of satellite constellations, which increase their overall temporal resolution and ground coverage for Earth observation. However, it is difficult for one single university or institution to maintain a satellite constellation composed of many microsatellites. Recently, the Asian Microsatellite Consortium (AMC) comprising 16 space agencies and universities from nine Asian nations has been created to develop microsatellite technologies and use collected data relating to the environment and natural disasters, etc. This international framework is the first step to share remote sensing data from the microsatellites by the members of the consortium, instead of making a satellite constellation by a single owner. The microsatellites such as the DIWATA-2 (Philippines), MicroDragon (Vietnam), and RISESAT (Japan) developed by the AMC members will be launched in the last quarter of 2018. This session is a unique opportunity to discuss microsatellite development and utilization in terms of international collaboration and data sharing. This session welcomes presentations on microsatellite remote sensing including satellite development and operation, sensor development and calibration, data analysis and utilization. We also seek presentations on ground and information systems, international collaborations, and educational programs using microsatellites.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MSD42-01] Present status of Asian Micro-satellite Consortium

*Yukihiro Takahashi[1] (1.Department of Cosmosciences, Graduate School of Science, Hokkaido University)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MSD42-02] **Updates on the Development of the Image Acquisition and Scheduler Portal for the Asian Microsatellite Consortium (AMC) from the Philippines' STAMINA4Space Program**

*Mark Edwin Tupas[1], Alvin Retamar[2], Gay Jane Perez[1], Joel Joseph Jr Marciano[2], Romer Kristi Aranas[1], Benjamin Joseph Jiao[1] (1.University of the Philippines - Diliman, 2.Department of Science and Technology - Advanced Science and Technology Institute)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MSD42-03] **Overview of MicroDragon, a microsatellite for ocean color observation**

*Huy Xuan Le[1], Thao Thi Nguyen[1], Junichi Kurihara[2] (1.Vietnam National Space Center, 2.Graduate School of Science, Hokkaido University)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MSD42-04] Updates on Philippines microsatellites DIWATA-1 and DIWATA-2

*Tetsuro Ishida[1], Mark Jayson Felix[2], Ellison Caparas Castro[2], Shielo Baes Namuco[2], Francisco Miguel Felicio[2], Harry Casimir Merida[2], Kaye Kristine Vergel[2], Gay Jane Perez[2], Joel Joseph Marciano[3,4], Yukihiro Takahashi[1] (1.Faculty of Science, Hokkaido University, 2.Institute of Environmental Science and Meteorology, University of the Philippines Diliman, 3.Advanced Science and Technology Institute, Department of Science and Technology, 4.Electrical and Electronics Engineering Institute, University of the Philippines Diliman)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MSD42-05] MICROSATELLITE TECHNOLOGY DEVELOPMENT STATUS IN MONGOLIA BASED ON ITS NEEDS

*Erdenebaatar Dashdondog[1], Begzsuren Tumendemberel[2], Turtogtokh Tumenjargal[3], Ulam-Orgikh Duger[4] (1.Senior Lecturer of the National University of Mongolia, 2.Hokkaido University, 3.Researcher National University of Mongolia, 4.Professor National University of Mongolia)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MSD42-06] Potential Agricultural Applications of Microsatellites for Malaysian Agriculture

*Abdul Rashid Bin Mohamed Shariff [1], Ahmad Shaqeer Mohamed Thaheer[2] (1.Universiti Putra Malaysia , 2.Hokkaido University)

Present status of Asian Micro-satellite Consortium

*Yukihiro Takahashi[1]

1. Department of Cosmosciences, Graduate School of Science, Hokkaido University

Satellite remote-sensing is useful for global monitoring. However, since the revisiting period by the most of the conventional satellite is relatively long compared to the time scale of disasters, etc., its application has been very limited. Here we promote “Asian Micro-satellite Consortium (AMC)” with a concept of “sharing”, namely, the sharing of satellite technology, data and applications. If the target pointing is possible, we can take images for any location once or twice a day only with one very small satellite. Therefore, on-demand image acquisition with several tens of micro-satellite under international agreement provides the continuous monitoring. We are developing the request system for disaster and environmental monitoring among the member countries, as well as 50-kg micro-satellites together with member countries. They can get frequent imaging opportunity at very low cost. Now the member institutions have several micro-satellites in space: RISING-2, DIWATA-1, DIWATA-2, RISESAT and MicroDragon with cutting edge spectral imagers. Moreover, we are negotiating some project with other few members as well. This world first system will provide revolutionary changes in the disaster and environmental management.

Keywords: micro-satellite, Asia, Consortium

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Updates on the Development of the Image Acquisition and Scheduler Portal for the Asian Microsatellite Consortium (AMC) from the Philippines' STAMINA4Space Program

*Mark Edwin Tupas[1], Alvin Retamar[2], Gay Jane Perez[1], Joel Joseph Jr Marciano[2], Romer Kristi Aranas[1], Benjamin Joseph Jiao[1]

1. University of the Philippines - Diliman, 2. Department of Science and Technology - Advanced Science and Technology Institute

The Asian Microsatellite Consortium (AMC) is a platform for forging meaningful scientific collaborations among Asian nations in space technology through the development and operation of small satellites for scientific earth observation. The Department of Science and Technology and its attached agencies –the Advanced Science and Technology Institute (DOST-ASTI) and the Philippine Council for Industry, Energy and Emerging Technology Research & Development (PCIEERD), together with the University of the Philippines (UP) participates in and contributes to the AMC through scientific research and development programs such as the PHL-Microsat and its successor, the Space Technology & Applications Mastery, Innovation and Advancement (STAMINA4Space). Through PHL-Microsat and STAMINA4Space, UP and DOST support the interaction and exchange of Filipino researchers with partners and enables access to the country's existing space assets, namely the microsatellites, DIWATA-1 and DIWATA-2, and ground receiving stations.

DIWATA-1 is a 50 kg. microsatellite that was deployed from the Japanese Kibo module in the International Space Station (ISS) on April 2016. In orbit for almost three (3) years and nearing the end of its orbital lifetime, DIWATA-1 has acquired more than 21,000 images of the Philippines and a total of over 36,000 including other parts of the world to support both scientific research and operational objectives. DIWATA-2, another 50 kg. microsatellite, on the other hand, was launched on October 29, 2018 by the JAXA HII-A rocket mission no. 40 to a Sun Synchronous Orbit (SSO) at approximately 600km. The optical cameras onboard DIWATA-2 consists of the HPT and the SMI with LCTF that were carried over end refined from the DIWATA-1 mission and Enhanced Resolution Camera (ERC) at 52.9m resolution to enhance imaging capability. With an expected orbital life of five (5) years, DIWATA-2 is expected to contribute to the AMC through target tasking and the reception, processing and distribution of relevant data.

In this regard, the STAMINA4Space program, through the Ground Receiving, Archiving, Science Product Development and Distribution (GRASPED) component, is currently undertaking the development of the satellite tasking and image acquisition scheduler software, which is expected to be part of a portal that will be accessed by the AMC members. The image acquisition scheduler works like a booking system by allowing AMC members and stakeholders to lodge image acquisition requests. The platform has been designed to follow a service oriented architecture in order to maintain a single source of information and to have flexibility in presentation. The core component of the distribution platform is the WebAPI , which handles geospatial queries through polygons or points. The user facing component of the platform is the web frontend, which consumes data from the WebAPI. It is based on Javascript and LeafletJS, a Javascript framework for interactive maps. Upon lodging of the image acquisition request, the system then identifies available satellites and ground segments for tasking and the member providers are subsequently notified and given the option to accept the tasks. According to the principles of cooperation under the AMC, acceptance and undertaking of the tasks by members is on a best-effort basis with certain requests

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gaining priority over others, e.g. in case of emergencies or natural disasters. The cycle ends with the delivery and acceptance of data. More than a resource for facilitating the sharing of both space and ground assets, the AMC portal is expected to contribute towards achieving sustainability of the consortium and of the space technology activities in the region. This presentation provides an update from the GRASPED project component of the Philippines STAMINA4Space program on the development of the scheduler along with related progress of DIWATA-1 and DIWATA-2 microsatellites.

Keywords: Asian Microsatellite Consortium, DIWATA-1, DIWATA-2, Image Acquisition Tasking

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Overview of MicroDragon, a microsatellite for ocean color observation

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1. Vietnam National Space Center, 2. Graduate School of Science, Hokkaido University

MicroDragon is an Earth observation satellite with the weight of 50kg and size of 50x50x50 centimeters cube. MicroDragon was developed with participation of 36 Vietnamese engineers from Vietnam National Space Center, Vietnam Academy of Science and Technology, who studied space technology in five Japanese universities (The University of Tokyo, Keio University, Tohoku University, Kyushu Institute of Technology, and Hokkaido University). Starting the manufacturing in 2013, MicroDragon has successfully been completed and tested in 2018 with the strong support of Japanese professors and experts.

The main mission of MicroDragon satellite is ocean color observation to assess coastal water quality and locate living resource. The target of the MicroDragon is to enhance observation of the ocean color and the phenomena in the coastal region as well as the cloud detection and the atmospheric correction. The system will provide data that researchers and scientists in fishery field and oceanography use to analysis and distribute information to fishermen and environmental managers.

For applications in the coastal zone, high spatial resolution, high spectral resolution, and many spectral bands are required. Image data of the old sensors can provide each of them but not all. With advantages of a new technique of Liquid Crystal Tunable Filter (LCTF), all three parameters can be included by a sensor. The LCTFs are optical filters that use electronically controlled liquid crystal elements to transmit a selectable wavelength of light and exclude others. The LCTFs are often used in multispectral imaging or hyperspectral imaging systems because of their high image quality and rapid tuning in small increments (1 nm) over the wide range of wavelengths. Moreover, the LCTF sensor that is small, light and low power consumption is suitable to install in a micro-satellite.

The MicroDragon carries two main scientific instruments including a Space-borne Multispectral Imager (SMI) and a Triple Polarization Imager (TPI). The SMI uses two LCTFs with one in the visible spectrum and another in the near-infrared spectrum for the ocean color observation. The TPI consists of three LCTF cameras, each camera’ s polarizer tilted 60° to the others to observe the polarized solar radiance reflected from the predefined targets for atmospheric correction.

MicroDragon was successfully launched on 18 January 2019 with 6 other technology demonstration satellites by Epsilon rocket from the Uchinoura Space Center in southwestern Japan. After launching, satellite also already communicated and controlled by a ground station and control center in ISAS/JAXA and the University of Tokyo. First images of satellite were sent to ground station after 4 days from launch time.

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Updates on Philippines microsatellites DIWATA-1 and DIWATA-2

*Tetsuro Ishida[1], Mark Jayson Felix[2], Ellison Caparas Castro[2], Shielo Baes Namuco[2], Francisco Miguel Felicio[2], Harry Casimir Merida[2], Kaye Kristine Vergel[2], Gay Jane Perez[2], Joel Joseph Marciano[3,4], Yukihiro Takahashi[1]

1. Faculty of Science, Hokkaido University, 2. Institute of Environmental Science and Meteorology, University of the Philippines Diliman, 3. Advanced Science and Technology Institute, Department of Science and Technology, 4. Electrical and Electronics Engineering Institute, University of the Philippines Diliman

The PHL-Microsat program, funded by the Department of Science and Technology (DOST) through the Philippine Council for Industry, Energy and Emerging Technology Research and Development (PCIEERD), is a collaboration between the University of the Philippines Diliman, Hokkaido University, Tohoku University, and the Advanced Science and Technology Institute (ASTI) of the DOST. Under this program, two 50-kg class microsatellites, DIWATA-1 and DIWATA-2 were designed and developed and the continuing development of small satellites is now being pursued by the Space Technology & Applications Mastery, Innovation and Advancement (STAMINA4Space) Program as a successor to PHL-Microsat.

DIWATA-1 was released into orbit from the International Space Station on April 27, 2016 and is currently operated at an altitude of ~346 km. More than two years after the release of DIWATA-1, DIWATA-2 was launched via H-IIA rocket from Japan’ s Tanegashima Space Center on October 29, 2018. The second microsatellite has a sun-synchronous orbit with an altitude of ~595 km. Both satellites carry advanced optical systems namely, the High Precision Telescope (HPT) and the Spaceborne Multispectral Imager (SMI) in addition to other cameras. The HPT in both microsatellites can simultaneously capture an image in the blue, green, red, and near-infrared range. It has a ground sampling distance (GSD) of ~2.6 m and ~4.5 m at nadir for DIWATA-1 and DIWATA-2, respectively. On the other hand, the SMI is capable of sensing several spectral bands between 450nm to 1050nm with ~53.1 m and ~121.6 m GSD for DIWATA-1 and DIWATA-2, respectively. The Wide Field Camera (WFC) is a fish eye camera with a field of view of 180 x 134 degrees. This is used in imaging cloud patterns and weather disturbances. Since the start of operation, both DIWATA-1 and DIWATA-2 have been capturing images of various locations in the Philippines. These images are processed to derive geophysical and application products that are useful in monitoring agricultural and aquatic resources. In this presentation, we will highlight land products and coastal and inland water applications. Land applications were produced from the visible and near infrared bands of SMI where vegetation indices namely NDVI and GNDVI. These are used to assess the health and density of vegetation as well as classify areas of agriculture, built-ups, bare soil and river or inland water networks. For water applications, potential capability to assess the health and quality of coastal and inland waters in the Philippines is shown. Retrievals of water quality parameters such as water leaving reflectance and turbidity were done. Furthermore, HPT, SMI and WFC were used to observe cloud patterns and estimate cloud top height. The accuracy assessment and limitations of these satellite-derived products will also be presented.

Acknowledgements: The control, operation, and acquisition of the satellite data are currently being handled by the Philippine Earth Data Resource Observation Center (PEDRO), which is managed by the Department of Science and Technology Advanced Science and Technology Institute (DOST-ASTI). This work was also supported by Japan Science and Technology Agency (JST) and Japan International Cooperation Agency (JICA) under SATREPS.

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Keywords: Microsatellite, Earth Observation, Remote Sensing

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MICROSATELLITE TECHNOLOGY DEVELOPMENT STATUS IN MONGOLIA BASED ON ITS NEEDS

*Erdenebaatar Dashdondog[1], Begzsuren Tumendemberel[2], Turtogtokh Tumenjargal[3], Ulam-Orgikh Duger[4]

1. Senior Lecturer of the National University of Mongolia, 2. Hokkaido University, 3. Researcher National University of Mongolia, 4. Professor National University of Mongolia

The National University of Mongolia is one of the main players on space technology development in Mongolia. The Laboratory of National University of Mongolia successfully launched Mongolian very first satellite (1U cubesat) in 2017 under BIRDS project. The project outcome was to prepare experienced initial engineers in the satellite engineering field. After the project, country had to make next steps toward to space technology. One step is Microsatellite technology development in Mongolia collaborating with the Hokkaido University of Japan. In the framework of this collaboration, some universities, including National University of Mongolia, have enrolled to the Asian Microsatellite Consortium (AMC). In January of 2018, National University of Mongolia organized a Microsatellite mission and needs definition workshop at first time. The low population density, wide land, rich natural resources and nomadic life culture make unique needs of space technology and its application for Mongolia. Also, Hyperspectral imagery of the Microsatellite could be the best suitable solution of the Mongolian Space Technology field. Applications of the hyperspectral imagery of the Microsatellite shall be well-developed. Researches and development of applications are being conducted on imagery of LCTF camera which is the main payload of the Microsatellite with the cutting-edge technology and the Unmanned Airborne Vehicle measurement method. In this presentation, Mongolian current status of the Microsatellite technology development and needs will be presented.

Keywords: Microsatellite, Hyper-spectral imagery, Space Collaboration

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Potential Agricultural Applications of Microsatellites for Malaysian Agriculture

*Abdul Rashid Bin Mohamed Shariff [1], Ahmad Shaqeer Mohamed Thaheer[2]

1. Universiti Putra Malaysia , 2. Hokkaido University

Malaysia is 330,803 km^2 and located in Southeast asia. It comprises two major land masses, that is Peninsular Malaysia and the states of Sabah/Sarawak in the island of Borneo. The South China Sea separates these two land masses. Flying distances between Kuala Lumpur, the capital city located in Peninsular Malaysia to Kota Kinabalu, the capital of Sabah and to Kuching, the capital of Sarawak are 2 hrs 30 minutes and 1 hr 45 minutes respectively. As can be seen this is a fairly wide coverage for which imaging from space is necessary to support viability of agriculture, fisheries, environment, meterology, natural disasters and so on. Malaysia' s early imaging from space satellites used the Tiungsat and Razaksat satellites respectively. Valuable lessons were learnt which clearly demonstrated the need for future image data from space.

With current developments, the idea of using microsatellites as platforms for image acquisitions becomes very attractive as a practical and low cost approach is made available. Though there are a multitude of applications possible with data acquired by microsatellites, this presentation will focus on agriculture applications. Malaysia has 5 millon ha of land under oil palm cultivation. Oil palm is an important food for most of the world, it is the most versatile and efficient vegetable oil in the world, yielding more per hectare than any other edible vegetable oil crop. Currently environmental and nature groups based in Europe have been critical about oil palm cultivation in Malaysia and Indonesia. However, oil palm is cultivated in a systematic and regulatory manner in Malaysia, with 50% of the country still remaining intact as forest. Use of microsatellite data will ensure efficient and effective monitoring of this forest areas from illegal land clearance, illegal logging and other activities detrimental to the environment. Up to date information on landuse for oil palm and forestry can be obtained at very frequent temporal intervals to counter any criticisms on concerns on oil palm cultivation in Malaysia.

Use of such imageries will also help in the precision agriculture applications particularly on using variable rate applications in the oil palm plantations and in paddy farming particularly, with potential applications for example for rubber cultivation, cocoa and pineapples. Apart from fertilizer applications, crop growth monitoring, surveillance against pests and diseases and harvesting are further applications of the imaging technologies. Based on these requirements, the critical bands, its spectral and spatial resolutions identified through local research will be used in the collaborative development of sensors in the satellite building program. Such positive and synergistic efforts will lead to appropriate images being acquired for the needs being addressed.
As crops planted in Malaysia have commonality with crops in Southeast Asia, primarily with Indonesia, Thailand, Philippines, Vietnam and Cambodia, collaborative efforts can be made to share and exchange vital information on the related crops. Thus the microsatellites will not only help to acquire data, but will help bring these neighboring nations closer together.

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[J] Poster | M (Multidisciplinary and Interdisciplinary) : M-TT Technology & Techniques

Sun. May 26, 2019 10:45 AM - 12:15 PM JST | Sun. May 26, 2019 1:45 AM - 3:15 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_11

[M-TT48] Frontiers in Geochemistry

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Tetsuya Yokoyama(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Hajime Obata(Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo)

In modern earth and planetary sciences, many new findings have been obtained by using state-of-the-art technique. These new findings include highly precise and accurate data, which is supported by recent developments of the new analytical methods. To use these data correctly and effectively, we need to deepen our knowledge on the methodology. This session aims at providing an opportunity for various geoscientists to get together and have a strategic discussion on frontiers in geochemistry and cosmochemistry. Especially, researchers, who would like to apply such innovative techniques, will have chances to discuss with those who work on devising new geochemical methods. We welcome a wide range of cutting-edge geochemical topics, including technical development, which have a potential for breakthrough of earth and planetary sciences. Any presentations related to the direction of geochemistry and cosmochemistry in future are also welcome. We expect wide-ranged and future-oriented discussion to develop geochemistry and cosmochemistry.

[MTT48-P01] Noble gas isotope analysis using a multi-turn time-of-flight mass spectrometer

*Hirochika Sumino[1], Yoshihide Akiyama[1] (1.Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo)

[MTT48-P02] Determination of picomolar of zirconium, hafnium, niobium and tantalum in seawater using chelating resin and subsequent ICP-MS determination

*Hajime Obata[1], Lutfi M. Firdaus[2], Asami S. Mashio[3], Taejin Kim[4], Jason McAlister[5], Toshitaka Gamo[1] (1.Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo, 2.Graduate School of Science Education, University of Bengkulu, Bengkulu, Indonesia, 3.College of Science and Engineering, Kanazawa University, Kanazawa, Japan, 4.School of Earth and Environmental Sciences, Seoul National University, Korea, 5.Department of Earth, Ocean, and Atmospheric Sciences, University of British Columbia, Canada)

[MTT48-P03] Development of ^{3}H-^{3}He groundwater dating method

*Nomata Naoki[1], Hirochika Sumino[1] (1.Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo)

[MTT48-P04] In-situ and meteoric 10Be and 26Al measurements: Improved preparation and application at the University of Tokyo

*Yusuke Yokoyama[1,2,3], Masako Yamane[7], Atsunori Nakamura[4], Yosuke Miyairi[1], Kazuho Horiuchi[5], Takahiro AZE[1], Hiroyuki Matsuzaki[6], Yoshiki Shirahama[4], Yuka Ando[1] (1.Atmosphere and Ocean Research Institute, University of Tokyo, 2.Department of Earth and Planetary Science, University of Tokyo, 3.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, 4.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 5.Graduate School of Science and Technology, Hirosaki University, 6.Micro Analysis Laboratory, Tandem Accelerator, University of Tokyo, 7.Division for Chronological Research, Institute for Space–Earth, Environmental Research, Nagoya University)

[MTT48-P05] Development of seawater stable Ba isotope analysis by DS-TIMS technique

*Shigeyuki Wakaki[1], Yuki Tezuka[2], Takashi Miyazaki[3], Keiji Horikawa[2] (1.Kochi Institute for Core Sample Research, JAMSTEC, 2.Univ. of Toyama , 3.Department of Solid Earth Geochemistry, JAMSTEC)

[MTT48-P06] Sequential radiocarbon measurement on peaty sediments to reconstruct high precision age model of mash deposits

*Yosuke Miyairi[1], Reisuke Kondo[2], Akihiro Yokota[3], Kiyoyuki Shigeno[3], Hiroko Fujita[4], Yusuke Yokoyama[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Kogakkan University, 3.Meiji consultant co.,ltd., 4.The Field Science Center for Northern Biosphere, Hokkaido University)

[MTT48-P07] Preliminary analysis of nucleosynthetic Sr isotope anomalies in amoeboid olivine aggregates from the Allende meteorite

*Yuki Masuda[1], Tetsuya Yokoyama[1], Kunihiro Myojo[1], Satoki Okabayashi[1] (1.Tokyo Institute of Technology)

[MTT48-P08] Measurement of diamagnetic susceptibility and magnetic separation and material identification of organic matter using small permanent magnet

*Keiji Hisayoshi[1], Hiroki Fukuyama[2], Chiaki Uyeda[2], Kentaro Terada[2] (1.Dept. of Earth and Space Science, School of Science, Osaka University, Otemae High School of Osaka prefecture, 2.Dept. of Earth and Space Science School of Science, Osaka University)

[MTT48-P09] Geochemistory and chronology of five howardites, Y-7308, Y-003125, Y-000428, NWA 1929, and NWA 6920

*Motoi Okada[1], Makiko K. Haba[1], Keisuke Nagao[2], Tetsuya Yokoyama[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2.Korea Polar research Institute)

[MTT48-P10] Non-destructive elemental analysis of a carbonaceous chondrite with direct current Muon beam at MuSIC

*Murota Yuta[1], Kentaro Terada[1] (1.Department of Earth and Space Science, Graduate School of Science, Osaka University)

[MTT48-P11] **Nucleosynthetic Sr and Nd isotopic anomalies of bulk differentiated meteorites**

*Ryota Fukai[1], Kei Sugimoto[1], Tetsuya Yokoyama[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

Noble gas isotope analysis using a multi-turn time-of-flight mass spectrometer

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Active volcanoes can cause devastating destruction, and as such, it would be desirable to be able to predict these disasters before their occurrence. One possibility involves measuring helium isotope ratio (^{3}He/^{4}He), which shows different values in geochemical reservoirs such as the atmosphere, ocean, crust, and mantle depending on the balance of primordial (relatively enriched in ^{3}He compared to the atmosphere) and radiogenic (predominantly ^{4}He) helium. The ^{3}He/^{4}He ratios of hot springs and groundwater around a volcano have values between magmatic (up to 1.1 $\times 10^{-5}$ or more) and crustal (less than 1 $\times 10^{-7}$) helium isotope ratios, the latter resulting from dissolution of radiogenic helium into groundwater from crustal rocks. When magma becomes active, the ^{3}He/^{4}He ratios of nearby hot springs/groundwater may increase as the relative contribution of magmatic helium is expected to be higher. Such ^{3}He/^{4}He increases preceding volcanic eruptions have been reported for El Hierro, Canary Islands [1], Mt. Etna, Italy [2], and Ontake, Japan [3]. The ^{3}He/^{4}He ratio of hot springs/groundwater around a volcano has great potential for monitoring magmatic activity. Currently, magnetic-sector mass spectrometry is used to measure ^{3}He/^{4}He, however, adequate mass resolution to discriminate ^{3}He$^+$ from HD$^+$ and a high-vacuum line to purify and separate helium from other gaseous species are required to measure ^{3}He/^{4}He ratios because helium concentration is generally quite low (1-100 ppmv in gas samples or 1-100 ppt in water samples) [4, 5]. Moreover, ^{3}He accounts for only 0.1-10 ppm of total helium. For these reasons, helium isotope analysis is limited to a suitable laboratory, and on-site, real-time monitoring of ^{3}He/^{4}He around a volcano is almost impossible.

We have been developing a new technique of noble gas analysis using “infiTOF” (infiTOF-UHV, MSI-Tokyo, Inc., Tokyo, Japan), which is a small, portable, time-of-flight (TOF) mass spectrometer derived from the MULTUM-S II multi-turn TOF mass spectrometer and is capable of high mass resolution [6, 7], in order to monitor ^{3}He/^{4}He ratio in volcanic gas on site. The high mass resolution achieved by infiTOF (>30,000) is more than enough to distinguish ^{3}He$^+$ and ^{20}Ne$^+$ from their interferences, HD$^+$ and ^{40}Ar^{++}, respectively. However, sensitivity of normal infiTOF was not high enough to analyze noble gases in volcanic gas because most of the noble gas molecules admitted to the infiTOF were pumped out by a vacuum pump before ionized by an electron ionization source. To increase ionization efficiency by suppressing the number of exhausted gas molecules, we installed a gate valve between the ion source and pump. A getter pump, which absorbs active gases but not noble gases, was also installed to keep the pressure in the ion source low during the operation. Furthermore, we made an attempt to improve sensitivity by making a smaller aperture between the ion source and mass analyzer to reduce the number of noble gas molecules leaking out to the mass analyzer before ionized. Currently the 140 times sensitivity compared to that of normal infiTOF has been achieved. Although ^{3}He in natural samples has not yet been observed with our infiTOF, of which ion current signals collected by a secondary electron multiplier are averaged for each flight cycle, it is expected to be detected in the future by processing the signals with pulse counting method [8, 9].

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Keywords: noble gas, multi-turn time-of-flight mass spectrometer, volcanic gas, isotope ratio

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Determination of picomolar of zirconium, hafnium, niobium and tantalum in seawater using chelating resin and subsequent ICP-MS determination

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It has been known that Zr, Hf, Nb and Ta are high field strength elements (HFSE) belonging to group IV and V in the periodic table. Among these elements, Zr-Hf and Nb-Ta are geochemical twin elements who have similar chemical properties (i.e., ionic charge and radius) in crustal materials and rocks. Contrastingly, the ratios of Zr/Hf and Nb/Ta in seawater are strongly fractionated, and can be used as chemical tracers for the movement of water masses in the modern ocean and as a proxy for paleo-ocean circulation (Firdaus et al., 2011; Frank, 2011). However, for example, the average Zr concentration is 250 pmol/kg in deep seawater, which is more than 6 order of magnitude lower than those in rock materials. It is still challenging for us to determine sub-picomolar to picomolar of HFSE in seawater.

In this study, we developed a simple method to determine sub-picomolar to picomolar of dissolved Zr, Hf, Nb and Ta in seawater using chelating resin column preconcentration and ICP-MS. With mini-columns filled with commercially available chelating resin, HFSE were preconcentrated by 50 times. We obtained low blank values and good recovery enough to determine HFSE in open ocean surface waters. The detection limits, calculated from the procedural blank values, were 0.15 pmol/kg for Zr, 0.03 pmol/kg for Hf, 0.06 pmol/kg for Nb and 0.03 pmol/kg for Ta, respectively.

Using the new method, we revealed distributions of Zr, Hf, Nb and Ta in open ocean, the North Pacific Ocean, North Atlantic Ocean, Indian Ocean and in the marginal sea, Andaman Sea and Gulf of Thailand. We will discuss the fractionations of Zr–Hf and Nb–Ta in the marine environments.

Keywords: Zr, Hf, Nb and Ta, high field strength elements, seawater

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Development of ^{3}H-^{3}He groundwater dating method

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Residence time of groundwater is an important parameter to elucidate groundwater flow system. We are developing the ^{3}H-^{3}He method, which is one of dating methods to estimate groundwater residence time ranging from several months to 120 years. In regions where water circulation is relatively active like those in Japan, this method is useful because it is considered that there are few groundwater with residence time more than several thousand years. The best advantage of this method is that it is applicable to accurately determine an age of young water compared to other methods (CFC & SF_6method and ^{36}Cl method, etc.), because initial ^{3}H concentration is directly determined as the sum of ^{3}He and ^{3}H in the water at present, if the groundwater flow system has been a closed system for ^{3}He and ^{3}H until its discharge. The age determined by the ^{3}H analysis only requires an assumption of the initial ^{3}H concentration based on the record of the past precipitation, therefore it is difficult to determine unambiguous groundwater age (Mahara *et al.*, 1993). In the ^{3}H-^{3}He dating method,^{3}He concentration in a water sample is measured first by degassing of water in vacuum, and after a few months' storage, ^{3}He produced from the decay of ^{3}H in the sample is measured to determine^{3}H concentration at the time of degassing. Thus, how the water sample is well degassed during the first analysis and how leaking of ambient helium into the degassed water is suppressed are crucial to determine small amount of ^{3}H. We analyzed standard water samples provided by IAEA with known ^{3}H concentrations to evaluate accuracy and precision of our method. When we compared the ^{4}He concentrations of the samples analyzed just after degassing and those analyzed after storage for one month, the ^{4}He concentration was extremely large in the samples stored for one month. As this indicates that the air helium intruded into the degassed sample during storage, we examined various ways to seal the sample container to prevent intrusion. This presentation will discuss developing of this method and how it will be applied to groundwater study in the future.

Keywords: groundwater

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In-situ and meteoric 10Be and 26Al measurements: Improved preparation and application at the University of Tokyo

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Cosmogenic radionuclides have been widely used to decipher Earth surface processes. At the University of Tokyo Accelerator Mass Spectrometry facility (5 MV Tandem accelerator), we have been measuring both in-situ and meteoric cosmogenic 10Be and 26Al. In this presentation, we report some development of methodology, including how to prepare target samples chemically to reduce their background. We then introduce some examples using the method to provide further insights into earth surface processes. These studies include: i) exposure to reveal the history of the growths and decays of the Antarctic ice sheet, ii) studying ice shelf collapse history, iii) palaeomagnetic excursion reconstructions using ice cores, iv) understanding the erosion rates using depth profiles of mid latitude outcrops, v) providing the timing of impact crater formation.

Reference: Yokoyama et al (2019) *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atom*. https://doi.org/10.1016/j.nimb.2019.01.026.

Keywords: Cosmogenic nuclides, Accelerator Mass Spectrometry

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Development of seawater stable Ba isotope analysis by DS-TIMS technique

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Depth profile of Ba in the ocean is characterized by nutrient-type distribution: the surface seawater has low Ba concentrations whereas the bottom water has high Ba concentrations. Barite formation in the ocean surface effectively removes Ba from the surface water. Part of the settling barite particles dissolve during the descent transporting Ba into deeper part of the ocean. The barite precipitation chemistry from seawater accompanies Ba stable isotope fractionation (von Allmen et al., 2010). Therefore, seawater Ba stable isotope composition is heterogeneous and variable in vertical directions (Horner et al., 2015). Also, the stable Ba isotopic composition of surface waters seems to be sensitive to riverine input and thus is a potential tracer of water mass interactions and ocean cycling (Cao et al., 2016).
The variation of stable Ba isotope ratios in the ocean is on the order of sub-permil. Therefore, detection of the seawater Ba isotope ratio changes requires high-precision analytical technique. In this study, we developed a method to analyze seawater Ba stable isotope composition with high- precision and high-accuracy using double-spike thermal ionization mass spectrometry (DS-TIMS). The spike used in this study was ^{134}Ba-^{136}Ba double spike with ^{134}Ba/^{136}Ba ratio of 2.5. Ba isotope ratios were measured with Thermo Triton TIMS in Kochi Core Center. Mass spectrometric conditions as well as conditions of double-spike data analysis were thoroughly optimized by repeated analysis of Ba reagents (NIST SRM3104a and an in-house reference reagent) to obtain the highest precision from a single dataset. With the optimized analytical conditions, the external precision of the $\delta^{138/134}$Ba value of multiple reagent analyses was +/- 0.01 ‰(2SD, n = 6). We will also discuss about the remaining issues for seawater analyses.

Keywords: Ba stable isotopes, double spike technique, seawater

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Sequential radiocarbon measurement on peaty sediments to reconstruct high precision age model of mash deposits

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Peat deposits that develop in wetlands are easy to radiocarbon dating because they contain a lot of carbon. However, peat has uncertainty in estimating the age of sedimentation that the source of carbon supply is secondary, because organic matter is not a biological body, but mainly decomposed matter of biological bodies. Biological disturbance is unlikely to occur in an anaerobic environment where peat deposits. In addition, the deposition rate often does not change much. Even if the deposition rate changes, it is guaranteed that the sediments are older than the sediments in the lower layer, according to the law of stratum accumulation, so sampling should be done at period intervals much shorter than the fluctuation cycle of radioactive carbon concentration If you do, you will be able to determine high precision chronology.

Blaauw et al. (2003, QSR) compares the calendar year calibration curve with the continuously sampled radiocarbon dating values, assuming that the peat layer deposition rate does not change for a certain period, Can be estimated.

Although this approach has been tried (eg Ishizawa et al., 2017, QG) to apply tsunami sediments contained in peat deposits to high precision age dating, verification of accuracy using known age class I have not been touched.
Therefore, in this study, we aimed to verify the age determination accuracy by seeing the age by the peat-wiggle matching method for the tephra containing layer whose eruption age is clear by the history record.

Keywords: Radiocarbon dating, Wiggle matching, Tephra

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Preliminary analysis of nucleosynthetic Sr isotope anomalies in amoeboid olivine aggregates from the Allende meteorite

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Recent innovations in mass spectrometric technology revealed that chondrites and their components possess distinct stable isotope ratios from the terrestrial values for various heavy elements including Ti, Cr, Sr, Mo, Ru, Ba, and Nd [1,2]. The isotopic variabilities, which are recognized as nucleosynthetic isotope anomalies in meteorites, suggest that the isotopic compositions of these elements were not homogeneous in the early Solar System as was previously believed. In particular, the extent of nucleosynthetic isotope anomalies in calcium and aluminum rich inclusions (CAIs) from carbonaceous chondrites, the oldest substance that condensed from a gaseous reservoir in the early Solar System, are larger than those in bulk aliquots of chondrites. Most recently, Myojo et al. [3] discovered that different groups of CAIs from the Allende meteorites show variable $^{84}Sr/^{86}Sr$ ratios, indicating the presence of multiple CAI source reservoirs with distinct isotopic compositions in the early Solar System.

In contrast to CAIs, little is known regarding nucleosynthetic isotope anomalies in amoeboid olivine aggregates (AOAs) from carbonaceous chondrites. AOAs are mostly composed of olivine with small refractory minerals including spinel and calcic pyroxene [4]. Their highly irregular shapes indicate that they are unmelted aggregates that condensed from a gaseous reservoir, although the bulk chemical compositions of AOAs are distinct from those of CAIs. Rather, their chemical compositions straddle CAIs and chondrules, making AOAs intriguing target to investigate the isotopic evolution for heavy elements in the early Solar System.

In this study, we report the $^{84}Sr/^{86}Sr$ ratios in AOAs from the Allende meteorite. Unlike CAIs and chondrules, it is difficult to sample irregular shaped AOAs by handpicking without including the other components such as matrix. To overcome this problem, we collected the powdered AOA sample by the micro-milling technique [3]. Additionally, we ablated the same AOA sample by a femto-second laser with He gas flow to capture the aerosol sample with a membrane filter. The collected samples were dissolved with acid, followed by the separation of Sr by extraction chromatography using Sr Resin (Eichrom). The $^{84}Sr/^{86}Sr$ ratios in the AOA samples were measured by TIMS (TRITON plus, Thermo Fisher Scientific) with the dynamic multicollection method. The obtained $^{84}Sr/^{86}Sr$ ratios are reported as $\mu^{84}Sr$ notation that represents the 10^6 relative deviation from a standard material, NIST 987. The two AOA samples showed positive $\mu^{84}Sr$ values (micro-milling: 70 ±156 ppm; laser ablation: 108 ±91 ppm). This result indicates that refractory inclusions in the AOA sample possess nucleosynthetic Sr isotope anomalies akin to those in Type B CAIs [3]. Therefore, the refractory inclusions in AOAs would have condensed from a gaseous reservoir from which the precursor of type B CAIs have condensed.

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Measurement of diamagnetic susceptibility and magnetic separation and material identification of organic matter using small permanent magnet

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Generally, solid particles released in the microgravity space perform translational motion by magnetic potential. The velocity of the particle does not depend on the mass of the particle but depends only on the magnetic susceptibility specific to the materials. Therefore, by comparing the magnetic susceptibility obtained with the literature value, it is possible to identify the material of a single particle [1] [2] [3]. In previous studies, we have confirmed that it is possible to identify diamagnetic materials of inorganic matter of mm ~ sub - mm size. Furthermore, we could observe translational motion in volatile solids ice (H_20) and dry ice (CO_2), and obtained diamagnetic susceptibility. In this study, we measured the diamagnetic susceptibility of various organic materials by using the same principle, and considered the possibility of organic matter separation and identification by magnetic field gradient.
Microgravity was generated using a short drop shaft. The length of the shaft is 1.8 m. The effective microgravity duration is about 0.5 seconds. The drop box for observing the translation was set in a box of 30 ×30 ×20 cm. The drop box consists of a small NdFeB magnetic circuit (B ~ 0.8 T) in glass tube, lighting, battery and high speed camera. The sample was set to the position where the gradient force was the maximum, and then released into the microgravity space. The diamagnetic organic sample translated out of the magnetic field. Magnetic susceptibility was determined from the motion of the sample.
By using a camera used for astronomical observation as a high-speed high-speed camera for this research, the accuracy of the position of the specimen has greatly improved[4].
This new practical possibility of a method of identifying and identifying solid organic matter and separating it by translating the mixture at different speed for each material was newly shown. Under the conventional measurement conditions, the difference in magnetic susceptibility could only be identified at the level of 10-7 emu/g. However, in this setting, we could identify the difference of 10-8 emu/g. We consider that this method is useful as an analytical method in two respects that it can be performed nondestructively by using a simple apparatus and that it can separate a mixture with an organic solid different from other chromatography methods. It is time-constrained in the microgravity environment on the ground. However, this method can measure with high accuracy and low budget within its constraints. Therefore, this method may be applied to any field regardless of some academic research / company research which is required to capture other short-term phenomena at high speed.
In this method, the magnetic susceptibility can be obtained with microgravity and magnetic field gradient. Therefore, there is a possibility of contributing to space exploration from the viewpoint that analysis can be done on the spot without having to bring out materials. When installing the equipment used for analysis on the ground to the planetary explorer, restrictions on size and weight and constraints on performance become major issues. However, this apparatus can translate the specimen over a long period of time with a weak magnetic field gradient in the astronomical space, which is a microgravity environment or only small gravity. Therefore, since the apparatus can be made small and lightweight, it is a great advantage in loading in a probing machine. In ESA's Rosetta mission, organic matter is actually detected in the comet, and the method for detailed analysis of organic matter on the spot can be a big demand in space exploration.

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Keywords: organic matter, magnetic separation, microgravity, diamagnetic susceptibility, identification, permanent magnet

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Geochemistory and chronology of five howardites, Y-7308, Y-003125, Y-000428, NWA 1929, and NWA 6920

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Howardites are polymict breccias composed of eucrites and diogenites that are most likely originated from the crust of asteroid 4-Vesta. The global mapping with high resolution imagery conducted during the NASA's Dawn mission revealed that the Vestan surface is largely covered with howarditic materials (Ammannito et al., 2013). Thus, howardites would provide information on the crustal and surface evolution of Vesta entailing impact events. Here, we attempt to obtain multiple chronological data of howardites including ^{244}Pu-Xe, ^{40}K-^{40}Ar, and (U-Th)/He ages. Since these decay systems have diverse closure temperatures of ≧900, ~300, 100–200℃, respectively (Shukolyukov and Begemann, 1996; Cassata et al., 2009; Reiners et al., 2012), the multi-chronology of howardites are useful to discuss the timing of thermal events on Vesta during a long period. Additionally, we obtained major and trace element compositions and cosmic-ray exposure (CRE) ages of howardites to identify the geochemical characteristics of each howardite sample and to determine the ejection timing from the parent body.

Five howardites, Northwest Africa (NWA) 1929, NWA 6920, Yamato (Y) -7308, Y-000428, and Y-003125, were used in this study. Textual observations were performed by field emission-electron probe micro analysis (FE-EPMA). The major and trace element compositions of bulk samples (~50 mg) were measured with inductively coupled plasma-mass spectrometry (ICP-MS). All noble gas compositions were measured using a noble gas mass spectrometer, modified-VG5400/MS-3, with a sample amount of ~200 mg.

The proportion of eucrite and diogenite that contributed to the howardite samples were estimated by using the Al and Ca contents in individual howardites with an assumption that the two end-members are represented by a basaltic eucrite Juvinas and a diogenite Tatahouine. The five howardites are composed of basaltic eucrite and diogenite with a proportion of 95:5 for NWA 1929, 47:53 for NWA 6920, 39:61 for Y-000428, 37:63 for Y-003125, and 22:78 for Y-7308.

NWA 6920 and Y-003125 yielded the ^{244}Pu-Xe ages of ~4550 Ma, which corresponds to the timing of the initial crystallization of eucritic crust or global crustal metamorphism that were deduced from the of zircon ages of basaltic eucrites (e.g., Misawa et al., 2005; Iizuka et al., 2015). In contrast, younger ^{244}Pu-Xe ages (~4470 Ma) were obtained from NWA 1929, Y-7308, and Y-000428, indicating the timing of high-temperature reheating possibly due to impact events. The ^{40}K-^{40}Ar ages of NWA 1929, NWA 6920, and Y-003125 are 3.6 ±0.2, 3.6 ±0.2, and 3.2 ±0.2 Ga, respectively, which are consistent with the ^{39}Ar-^{40}Ar ages of brecciated eucrites (3.3–4.1 Ga; Bogard, 2011). The ages obtained in this study represent the timing of reheating by impacts, which reached a temperature above ~300 ℃, after the initial magmatism of eucritic crust. The (U-Th)/He ages of NWA 1929, NWA 6920, and Y-003125 are 2.3 ±0.2, 0.8 ±0.1, and 2.3 ±0.2 Ga, respectively. The (U-Th)/He systematics in the howardites could have been disturbed by degassing events that occurred at some points during the ejection from Vesta and delivery to the Earth, in addition to the impact events on Vesta. Some HED (Howardite-Eucrite-Diogenite) meteorites are considered to have derived from vestoids that were ejected from the Vesta's south pole craters (e.g., Clenet et al., 2014). Because the (U-Th)/He age of NWA 6920 is in good agreement with the age of the southern crater Rheasilvia (1.0 ±0.2 Ga, Schenk et al., 2012), NWA 6920 might have been severely suffered from the impact event that formed the Rheasilvia crater. The ^{81}Kr-Kr CRE ages vary from ~10 to

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45 Ma, which is consistent with the previously reported CRE ages of howardites (~11–76 Ma, Eugster and Michel, 1995). Since the CRE ages of howardites cluster at the same period to those of eucrites and diogenites, the HED meteorite clan might have been launched from vestoids or Vestan surface at the same time.

Keywords: Howardite, noble gas, chronology

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Non-destructive elemental analysis of a carbonaceous chondrite with direct current Muon beam at MuSIC

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Electron- or X-ray-induced characteristic X-ray analysis has been widely used to determine chemical compositions of materials in vast research fields. In recent years, analysis of characteristic X-rays from muonic atoms, in which a muon is captured, has attracted attention because both a muon beam and a muon-induced characteristic X-ray have high transmission abilities. Here we report the first nondestructive elemental analysis of a carbonaceous chondrite using one of the world-leading intense direct current muon beam source (MuSIC; MUon Science Innovative Channel). We successfully detected characteristic muonic X-rays of Mg, Si, Fe, O, S and C from CI chondrite, of which carbon content is about 3 wt%. Because of its high sensitivity to carbon, non-destructive elemental analysis with a muon beam can be a novel powerful tool to characterize future retuned samples from carbonaceous asteroids.

Keywords: muon, non-destructive elemental analysis, Hayabusa2

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Nucleosynthetic Sr and Nd isotopic anomalies of bulk differentiated meteorites

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Nucleosynthetic isotope anomalies have been discovered in bulk meteorites for refractory heavy elements (e.g., Cr, Ru [1, 2]). In the most cases, the extent of isotope anomalies is variable across different types of meteorites. These results point to the existence of planetary-scale isotope heterogeneities, which are most likely caused by the heterogeneous distribution of presolar dust grains in the early Solar System.

Although nucleosynthetic isotopic anomalies of bulk chondrites have been extensively studied in the last decade (e.g., [3]), the high-precision isotopic data of trans-iron elements in differentiated meteorites are still limited. Commonly, the parent bodies of differentiated meteorites possessed earlier accretional ages than those of chondrites. The comparison for the nucleosynthetic isotopic anomalies between chondrites and differentiated meteorites must provide vital information for understanding the physicochemical evolution of the early Solar System. Here we focus on refractory lithophile elements (Sr and Nd), whose carrier grains are silicate dust grains that were main constituents in the protoplanetary disk. In this study, we report high precision Sr and Nd isotope data of bulk differentiated meteorites.

We investigated two eucrites (Béréba and Millbillillie), an aubrite (Norton County), and an angrite (D'Orbigny). Powdered samples were treated with H_2O and distilled acetone to reduce the effects of terrestrial alteration. Subsequently, these meteorite samples were digested with HF and HNO_3 under high temperature and high pressure using a high pressure digestion system (DAB-2, Berghof). After the high-pressure digestion, samples were dissolved with $HClO_4$ and HNO_3. For Sr and Nd isotope analysis, a 5-step column separation procedure was conducted. Sr and Nd isotopic compositions were measured with TIMS (Triton *Plus*). Sr and Nd isotopic ratio measurements were conducted with the 2-line and 3-line dynamic multi-collection methods, respectively, in which $^{84}Sr/^{86}Sr$, $^{142}Nd/^{144}Nd$, $^{143}Nd/^{144}Nd$, $^{145}Nd/^{144}Nd$, $^{148}Nd/^{144}Nd$, and $^{150}Nd/^{144}Nd$ ratios can be obtained by reducing the effect of Faraday cup deterioration. The Sr and Nd isotope ratios are reported in the μM notation that is parts par 10^6 relative deviations from the terrestrial rocks.

Most of the samples we measured showed Sr and Nd isotopic ratios indistinguishable from the terrestrial rocks. Béréba (eucrite) possessed the most deviated isotopic compositions from the terrestrial rocks (μ^{84}Sr = 16 ±24 ppm, μ^{145}Nd = 5.5 ±1.9 ppm, μ^{148}Nd = 9.6 ±11 ppm, and μ^{150}Nd = 9.4 ±22 ppm, 2SDs). The inconsistency of the isotopic compositions for the same meteorite group (Béréba and Millbillillie) would be attributed to the possible terrestrial alteration for Millbillillie [4].

The nucleosynthetic Sr and Nd isotope anomalies for Béréba were indistinguishable from the data for non-carbonaceous meteorites (enstatite and ordinary chondrites) [3]. In the μ^{84}Sr versus $\mu^{145, 148, 150}$Nd diagrams, Béréba are plotted on the mixing line of the isotopic compositions for terrestrial rocks and presolar SiC [5]. These data imply that the parent bodies for enstatite chondrites, ordinary chondrites, and eucrites were formed within homogeneous isotopic reservoir with respect to Sr and Nd in which a part of building blocks of the Earth were not formed.

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Keywords: early Solar System, isotopic heterogeneity, achondrites

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[J] Poster | M (Multidisciplinary and Interdisciplinary) : M-TT Technology & Techniques

Sun. May 26, 2019 5:15 PM - 6:30 PM JST | Sun. May 26, 2019 8:15 AM - 9:30 AM UTC | Poster Hall International Exhibition Hall8, Makuhari Messe_48

[M-TT48] Frontiers in Geochemistry

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Tetsuya Yokoyama(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Hajime Obata(Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo)

In modern earth and planetary sciences, many new findings have been obtained by using state-of-the-art technique. These new findings include highly precise and accurate data, which is supported by recent developments of the new analytical methods. To use these data correctly and effectively, we need to deepen our knowledge on the methodology. This session aims at providing an opportunity for various geoscientists to get together and have a strategic discussion on frontiers in geochemistry and cosmochemistry. Especially, researchers, who would like to apply such innovative techniques, will have chances to discuss with those who work on devising new geochemical methods. We welcome a wide range of cutting-edge geochemical topics, including technical development, which have a potential for breakthrough of earth and planetary sciences. Any presentations related to the direction of geochemistry and cosmochemistry in future are also welcome. We expect wide-ranged and future-oriented discussion to develop geochemistry and cosmochemistry.

[MTT48-P01] Noble gas isotope analysis using a multi-turn time-of-flight mass spectrometer

*Hirochika Sumino[1], Yoshihide Akiyama[1] (1.Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo)

[MTT48-P02] Determination of picomolar of zirconium, hafnium, niobium and tantalum in seawater using chelating resin and subsequent ICP-MS determination

*Hajime Obata[1], Lutfi M. Firdaus[2], Asami S. Mashio[3], Taejin Kim[4], Jason McAlister[5], Toshitaka Gamo[1] (1.Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo, 2.Graduate School of Science Education, University of Bengkulu, Bengkulu, Indonesia, 3.College of Science and Engineering, Kanazawa University, Kanazawa, Japan, 4.School of Earth and Environmental Sciences, Seoul National University, Korea, 5.Department of Earth, Ocean, and Atmospheric Sciences, University of British Columbia, Canada)

[MTT48-P03] Development of ^{3}H-^{3}He groundwater dating method

*Nomata Naoki[1], Hirochika Sumino[1] (1.Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo)

[MTT48-P04] In-situ and meteoric 10Be and 26Al measurements: Improved preparation and application at the University of Tokyo

*Yusuke Yokoyama[1,2,3], Masako Yamane[7], Atsunori Nakamura[4], Yosuke Miyairi[1], Kazuho Horiuchi[5], Takahiro AZE[1], Hiroyuki Matsuzaki[6], Yoshiki Shirahama[4], Yuka Ando[1] (1.Atmosphere and Ocean Research Institute, University of Tokyo, 2.Department of Earth and Planetary Science, University of Tokyo, 3.Department of Biogeochemistry, Japan Agency for Marine-Earth Science and Technology, 4.Geological Survey of Japan, National Institute of Advanced Industrial Science and Technology, 5.Graduate School of Science and Technology, Hirosaki University, 6.Micro Analysis Laboratory, Tandem Accelerator, University of Tokyo, 7.Division for Chronological Research, Institute for Space–Earth, Environmental Research, Nagoya University)

[MTT48-P05] Development of seawater stable Ba isotope analysis by DS-TIMS technique

*Shigeyuki Wakaki[1], Yuki Tezuka[2], Takashi Miyazaki[3], Keiji Horikawa[2] (1.Kochi Institute for Core Sample Research, JAMSTEC, 2.Univ. of Toyama , 3.Department of Solid Earth Geochemistry, JAMSTEC)

[MTT48-P06] Sequential radiocarbon measurement on peaty sediments to reconstruct high precision age model of mash deposits

*Yosuke Miyairi[1], Reisuke Kondo[2], Akihiro Yokota[3], Kiyoyuki Shigeno[3], Hiroko Fujita[4], Yusuke Yokoyama[1] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Kogakkan University, 3.Meiji consultant co.,ltd., 4.The Field Science Center for Northern Biosphere, Hokkaido University)

[MTT48-P07] Preliminary analysis of nucleosynthetic Sr isotope anomalies in amoeboid olivine aggregates from the Allende meteorite

*Yuki Masuda[1], Tetsuya Yokoyama[1], Kunihiro Myojo[1], Satoki Okabayashi[1] (1.Tokyo Institute of Technology)

[MTT48-P08] Measurement of diamagnetic susceptibility and magnetic separation and material identification of organic matter using small permanent magnet

*Keiji Hisayoshi[1], Hiroki Fukuyama[2], Chiaki Uyeda[2], Kentaro Terada[2] (1.Dept. of Earth and Space Science, School of Science, Osaka University, Otemae High School of Osaka prefecture, 2.Dept. of Earth and Space Science School of Science, Osaka University)

[MTT48-P09] Geochemistory and chronology of five howardites, Y-7308, Y-003125, Y-000428, NWA 1929, and NWA 6920

*Motoi Okada[1], Makiko K. Haba[1], Keisuke Nagao[2], Tetsuya Yokoyama[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology, 2.Korea Polar research Institute)

[MTT48-P10] Non-destructive elemental analysis of a carbonaceous chondrite with direct current Muon beam at MuSIC

*Murota Yuta[1], Kentaro Terada[1] (1.Department of Earth and Space Science, Graduate School of Science, Osaka University)

[MTT48-P11] **Nucleosynthetic Sr and Nd isotopic anomalies of bulk differentiated meteorites**

*Ryota Fukai[1], Kei Sugimoto[1], Tetsuya Yokoyama[1] (1.Department of Earth and Planetary Sciences, Tokyo Institute of Technology)

Noble gas isotope analysis using a multi-turn time-of-flight mass spectrometer

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Active volcanoes can cause devastating destruction, and as such, it would be desirable to be able to predict these disasters before their occurrence. One possibility involves measuring helium isotope ratio (^{3}He/^{4}He), which shows different values in geochemical reservoirs such as the atmosphere, ocean, crust, and mantle depending on the balance of primordial (relatively enriched in ^{3}He compared to the atmosphere) and radiogenic (predominantly ^{4}He) helium. The ^{3}He/^{4}He ratios of hot springs and groundwater around a volcano have values between magmatic (up to 1.1 $\times 10^{-5}$ or more) and crustal (less than 1 $\times 10^{-7}$) helium isotope ratios, the latter resulting from dissolution of radiogenic helium into groundwater from crustal rocks. When magma becomes active, the ^{3}He/^{4}He ratios of nearby hot springs/groundwater may increase as the relative contribution of magmatic helium is expected to be higher. Such ^{3}He/^{4}He increases preceding volcanic eruptions have been reported for El Hierro, Canary Islands [1], Mt. Etna, Italy [2], and Ontake, Japan [3]. The ^{3}He/^{4}He ratio of hot springs/groundwater around a volcano has great potential for monitoring magmatic activity. Currently, magnetic-sector mass spectrometry is used to measure ^{3}He/^{4}He, however, adequate mass resolution to discriminate ^{3}He$^+$ from HD$^+$ and a high-vacuum line to purify and separate helium from other gaseous species are required to measure ^{3}He/^{4}He ratios because helium concentration is generally quite low (1-100 ppmv in gas samples or 1-100 ppt in water samples) [4, 5]. Moreover, ^{3}He accounts for only 0.1-10 ppm of total helium. For these reasons, helium isotope analysis is limited to a suitable laboratory, and on-site, real-time monitoring of ^{3}He/^{4}He around a volcano is almost impossible.

We have been developing a new technique of noble gas analysis using “infiTOF” (infiTOF-UHV, MSI-Tokyo, Inc., Tokyo, Japan), which is a small, portable, time-of-flight (TOF) mass spectrometer derived from the MULTUM-S II multi-turn TOF mass spectrometer and is capable of high mass resolution [6, 7], in order to monitor ^{3}He/^{4}He ratio in volcanic gas on site. The high mass resolution achieved by infiTOF (>30,000) is more than enough to distinguish ^{3}He$^+$ and ^{20}Ne$^+$ from their interferences, HD$^+$ and ^{40}Ar^{++}, respectively. However, sensitivity of normal infiTOF was not high enough to analyze noble gases in volcanic gas because most of the noble gas molecules admitted to the infiTOF were pumped out by a vacuum pump before ionized by an electron ionization source. To increase ionization efficiency by suppressing the number of exhausted gas molecules, we installed a gate valve between the ion source and pump. A getter pump, which absorbs active gases but not noble gases, was also installed to keep the pressure in the ion source low during the operation. Furthermore, we made an attempt to improve sensitivity by making a smaller aperture between the ion source and mass analyzer to reduce the number of noble gas molecules leaking out to the mass analyzer before ionized. Currently the 140 times sensitivity compared to that of normal infiTOF has been achieved. Although ^{3}He in natural samples has not yet been observed with our infiTOF, of which ion current signals collected by a secondary electron multiplier are averaged for each flight cycle, it is expected to be detected in the future by processing the signals with pulse counting method [8, 9].

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Keywords: noble gas, multi-turn time-of-flight mass spectrometer, volcanic gas, isotope ratio

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Determination of picomolar of zirconium, hafnium, niobium and tantalum in seawater using chelating resin and subsequent ICP-MS determination

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It has been known that Zr, Hf, Nb and Ta are high field strength elements (HFSE) belonging to group IV and V in the periodic table. Among these elements, Zr-Hf and Nb-Ta are geochemical twin elements who have similar chemical properties (i.e., ionic charge and radius) in crustal materials and rocks. Contrastingly, the ratios of Zr/Hf and Nb/Ta in seawater are strongly fractionated, and can be used as chemical tracers for the movement of water masses in the modern ocean and as a proxy for paleo-ocean circulation (Firdaus et al., 2011; Frank, 2011). However, for example, the average Zr concentration is 250 pmol/kg in deep seawater, which is more than 6 order of magnitude lower than those in rock materials. It is still challenging for us to determine sub-picomolar to picomolar of HFSE in seawater.

In this study, we developed a simple method to determine sub-picomolar to picomolar of dissolved Zr, Hf, Nb and Ta in seawater using chelating resin column preconcentration and ICP-MS. With mini-columns filled with commercially available chelating resin, HFSE were preconcentrated by 50 times. We obtained low blank values and good recovery enough to determine HFSE in open ocean surface waters. The detection limits, calculated from the procedural blank values, were 0.15 pmol/kg for Zr, 0.03 pmol/kg for Hf, 0.06 pmol/kg for Nb and 0.03 pmol/kg for Ta, respectively.

Using the new method, we revealed distributions of Zr, Hf, Nb and Ta in open ocean, the North Pacific Ocean, North Atlantic Ocean, Indian Ocean and in the marginal sea, Andaman Sea and Gulf of Thailand. We will discuss the fractionations of Zr–Hf and Nb–Ta in the marine environments.

Keywords: Zr, Hf, Nb and Ta, high field strength elements, seawater

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Development of ^{3}H-^{3}He groundwater dating method

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Residence time of groundwater is an important parameter to elucidate groundwater flow system. We are developing the ^{3}H-^{3}He method, which is one of dating methods to estimate groundwater residence time ranging from several months to 120 years. In regions where water circulation is relatively active like those in Japan, this method is useful because it is considered that there are few groundwater with residence time more than several thousand years. The best advantage of this method is that it is applicable to accurately determine an age of young water compared to other methods (CFC & SF_6method and ^{36}Cl method, etc.), because initial ^{3}H concentration is directly determined as the sum of ^{3}He and ^{3}H in the water at present, if the groundwater flow system has been a closed system for ^{3}He and ^{3}H until its discharge. The age determined by the ^{3}H analysis only requires an assumption of the initial ^{3}H concentration based on the record of the past precipitation, therefore it is difficult to determine unambiguous groundwater age (Mahara *et al.*, 1993). In the ^{3}H-^{3}He dating method,^{3}He concentration in a water sample is measured first by degassing of water in vacuum, and after a few months' storage, ^{3}He produced from the decay of ^{3}H in the sample is measured to determine^{3}H concentration at the time of degassing. Thus, how the water sample is well degassed during the first analysis and how leaking of ambient helium into the degassed water is suppressed are crucial to determine small amount of ^{3}H. We analyzed standard water samples provided by IAEA with known ^{3}H concentrations to evaluate accuracy and precision of our method. When we compared the ^{4}He concentrations of the samples analyzed just after degassing and those analyzed after storage for one month, the ^{4}He concentration was extremely large in the samples stored for one month. As this indicates that the air helium intruded into the degassed sample during storage, we examined various ways to seal the sample container to prevent intrusion. This presentation will discuss developing of this method and how it will be applied to groundwater study in the future.

Keywords: groundwater

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In-situ and meteoric 10Be and 26Al measurements: Improved preparation and application at the University of Tokyo

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Cosmogenic radionuclides have been widely used to decipher Earth surface processes. At the University of Tokyo Accelerator Mass Spectrometry facility (5 MV Tandem accelerator), we have been measuring both in-situ and meteoric cosmogenic 10Be and 26Al. In this presentation, we report some development of methodology, including how to prepare target samples chemically to reduce their background. We then introduce some examples using the method to provide further insights into earth surface processes. These studies include: i) exposure to reveal the history of the growths and decays of the Antarctic ice sheet, ii) studying ice shelf collapse history, iii) palaeomagnetic excursion reconstructions using ice cores, iv) understanding the erosion rates using depth profiles of mid latitude outcrops, v) providing the timing of impact crater formation.

Reference: Yokoyama et al (2019) *Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atom*. https://doi.org/10.1016/j.nimb.2019.01.026.

Keywords: Cosmogenic nuclides, Accelerator Mass Spectrometry

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Development of seawater stable Ba isotope analysis by DS-TIMS technique

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Depth profile of Ba in the ocean is characterized by nutrient-type distribution: the surface seawater has low Ba concentrations whereas the bottom water has high Ba concentrations. Barite formation in the ocean surface effectively removes Ba from the surface water. Part of the settling barite particles dissolve during the descent transporting Ba into deeper part of the ocean. The barite precipitation chemistry from seawater accompanies Ba stable isotope fractionation (von Allmen et al., 2010). Therefore, seawater Ba stable isotope composition is heterogeneous and variable in vertical directions (Horner et al., 2015). Also, the stable Ba isotopic composition of surface waters seems to be sensitive to riverine input and thus is a potential tracer of water mass interactions and ocean cycling (Cao et al., 2016).
The variation of stable Ba isotope ratios in the ocean is on the order of sub-permil. Therefore, detection of the seawater Ba isotope ratio changes requires high-precision analytical technique. In this study, we developed a method to analyze seawater Ba stable isotope composition with high- precision and high-accuracy using double-spike thermal ionization mass spectrometry (DS-TIMS). The spike used in this study was ^{134}Ba-^{136}Ba double spike with ^{134}Ba/^{136}Ba ratio of 2.5. Ba isotope ratios were measured with Thermo Triton TIMS in Kochi Core Center. Mass spectrometric conditions as well as conditions of double-spike data analysis were thoroughly optimized by repeated analysis of Ba reagents (NIST SRM3104a and an in-house reference reagent) to obtain the highest precision from a single dataset. With the optimized analytical conditions, the external precision of the $\delta^{138/134}$Ba value of multiple reagent analyses was +/- 0.01 ‰(2SD, n = 6). We will also discuss about the remaining issues for seawater analyses.

Keywords: Ba stable isotopes, double spike technique, seawater

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Sequential radiocarbon measurement on peaty sediments to reconstruct high precision age model of mash deposits

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Peat deposits that develop in wetlands are easy to radiocarbon dating because they contain a lot of carbon. However, peat has uncertainty in estimating the age of sedimentation that the source of carbon supply is secondary, because organic matter is not a biological body, but mainly decomposed matter of biological bodies. Biological disturbance is unlikely to occur in an anaerobic environment where peat deposits. In addition, the deposition rate often does not change much. Even if the deposition rate changes, it is guaranteed that the sediments are older than the sediments in the lower layer, according to the law of stratum accumulation, so sampling should be done at period intervals much shorter than the fluctuation cycle of radioactive carbon concentration If you do, you will be able to determine high precision chronology.

Blaauw et al. (2003, QSR) compares the calendar year calibration curve with the continuously sampled radiocarbon dating values, assuming that the peat layer deposition rate does not change for a certain period, Can be estimated.

Although this approach has been tried (eg Ishizawa et al., 2017, QG) to apply tsunami sediments contained in peat deposits to high precision age dating, verification of accuracy using known age class I have not been touched.
Therefore, in this study, we aimed to verify the age determination accuracy by seeing the age by the peat-wiggle matching method for the tephra containing layer whose eruption age is clear by the history record.

Keywords: Radiocarbon dating, Wiggle matching, Tephra

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Preliminary analysis of nucleosynthetic Sr isotope anomalies in amoeboid olivine aggregates from the Allende meteorite

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Recent innovations in mass spectrometric technology revealed that chondrites and their components possess distinct stable isotope ratios from the terrestrial values for various heavy elements including Ti, Cr, Sr, Mo, Ru, Ba, and Nd [1,2]. The isotopic variabilities, which are recognized as nucleosynthetic isotope anomalies in meteorites, suggest that the isotopic compositions of these elements were not homogeneous in the early Solar System as was previously believed. In particular, the extent of nucleosynthetic isotope anomalies in calcium and aluminum rich inclusions (CAIs) from carbonaceous chondrites, the oldest substance that condensed from a gaseous reservoir in the early Solar System, are larger than those in bulk aliquots of chondrites. Most recently, Myojo et al. [3] discovered that different groups of CAIs from the Allende meteorites show variable $^{84}Sr/^{86}Sr$ ratios, indicating the presence of multiple CAI source reservoirs with distinct isotopic compositions in the early Solar System.

In contrast to CAIs, little is known regarding nucleosynthetic isotope anomalies in amoeboid olivine aggregates (AOAs) from carbonaceous chondrites. AOAs are mostly composed of olivine with small refractory minerals including spinel and calcic pyroxene [4]. Their highly irregular shapes indicate that they are unmelted aggregates that condensed from a gaseous reservoir, although the bulk chemical compositions of AOAs are distinct from those of CAIs. Rather, their chemical compositions straddle CAIs and chondrules, making AOAs intriguing target to investigate the isotopic evolution for heavy elements in the early Solar System.

In this study, we report the $^{84}Sr/^{86}Sr$ ratios in AOAs from the Allende meteorite. Unlike CAIs and chondrules, it is difficult to sample irregular shaped AOAs by handpicking without including the other components such as matrix. To overcome this problem, we collected the powdered AOA sample by the micro-milling technique [3]. Additionally, we ablated the same AOA sample by a femto-second laser with He gas flow to capture the aerosol sample with a membrane filter. The collected samples were dissolved with acid, followed by the separation of Sr by extraction chromatography using Sr Resin (Eichrom). The $^{84}Sr/^{86}Sr$ ratios in the AOA samples were measured by TIMS (TRITON plus, Thermo Fisher Scientific) with the dynamic multicollection method. The obtained $^{84}Sr/^{86}Sr$ ratios are reported as $\mu^{84}Sr$ notation that represents the 10^6 relative deviation from a standard material, NIST 987. The two AOA samples showed positive $\mu^{84}Sr$ values (micro-milling: 70 ±156 ppm; laser ablation: 108 ±91 ppm). This result indicates that refractory inclusions in the AOA sample possess nucleosynthetic Sr isotope anomalies akin to those in Type B CAIs [3]. Therefore, the refractory inclusions in AOAs would have condensed from a gaseous reservoir from which the precursor of type B CAIs have condensed.

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Measurement of diamagnetic susceptibility and magnetic separation and material identification of organic matter using small permanent magnet

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Generally, solid particles released in the microgravity space perform translational motion by magnetic potential. The velocity of the particle does not depend on the mass of the particle but depends only on the magnetic susceptibility specific to the materials. Therefore, by comparing the magnetic susceptibility obtained with the literature value, it is possible to identify the material of a single particle [1] [2] [3]. In previous studies, we have confirmed that it is possible to identify diamagnetic materials of inorganic matter of mm ~ sub - mm size. Furthermore, we could observe translational motion in volatile solids ice (H_20) and dry ice (CO_2), and obtained diamagnetic susceptibility. In this study, we measured the diamagnetic susceptibility of various organic materials by using the same principle, and considered the possibility of organic matter separation and identification by magnetic field gradient.
Microgravity was generated using a short drop shaft. The length of the shaft is 1.8 m. The effective microgravity duration is about 0.5 seconds. The drop box for observing the translation was set in a box of 30 ×30 ×20 cm. The drop box consists of a small NdFeB magnetic circuit (B ~ 0.8 T) in glass tube, lighting, battery and high speed camera. The sample was set to the position where the gradient force was the maximum, and then released into the microgravity space. The diamagnetic organic sample translated out of the magnetic field. Magnetic susceptibility was determined from the motion of the sample.
By using a camera used for astronomical observation as a high-speed high-speed camera for this research, the accuracy of the position of the specimen has greatly improved[4].
This new practical possibility of a method of identifying and identifying solid organic matter and separating it by translating the mixture at different speed for each material was newly shown. Under the conventional measurement conditions, the difference in magnetic susceptibility could only be identified at the level of 10-7 emu/g. However, in this setting, we could identify the difference of 10-8 emu/g. We consider that this method is useful as an analytical method in two respects that it can be performed nondestructively by using a simple apparatus and that it can separate a mixture with an organic solid different from other chromatography methods. It is time-constrained in the microgravity environment on the ground. However, this method can measure with high accuracy and low budget within its constraints. Therefore, this method may be applied to any field regardless of some academic research / company research which is required to capture other short-term phenomena at high speed.
In this method, the magnetic susceptibility can be obtained with microgravity and magnetic field gradient. Therefore, there is a possibility of contributing to space exploration from the viewpoint that analysis can be done on the spot without having to bring out materials. When installing the equipment used for analysis on the ground to the planetary explorer, restrictions on size and weight and constraints on performance become major issues. However, this apparatus can translate the specimen over a long period of time with a weak magnetic field gradient in the astronomical space, which is a microgravity environment or only small gravity. Therefore, since the apparatus can be made small and lightweight, it is a great advantage in loading in a probing machine. In ESA's Rosetta mission, organic matter is actually detected in the comet, and the method for detailed analysis of organic matter on the spot can be a big demand in space exploration.

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Keywords: organic matter, magnetic separation, microgravity, diamagnetic susceptibility, identification, permanent magnet

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Geochemistory and chronology of five howardites, Y-7308, Y-003125, Y-000428, NWA 1929, and NWA 6920

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Howardites are polymict breccias composed of eucrites and diogenites that are most likely originated from the crust of asteroid 4-Vesta. The global mapping with high resolution imagery conducted during the NASA's Dawn mission revealed that the Vestan surface is largely covered with howarditic materials (Ammannito et al., 2013). Thus, howardites would provide information on the crustal and surface evolution of Vesta entailing impact events. Here, we attempt to obtain multiple chronological data of howardites including ^{244}Pu-Xe, ^{40}K-^{40}Ar, and (U-Th)/He ages. Since these decay systems have diverse closure temperatures of ≧900, ~300, 100–200℃, respectively (Shukolyukov and Begemann, 1996; Cassata et al., 2009; Reiners et al., 2012), the multi-chronology of howardites are useful to discuss the timing of thermal events on Vesta during a long period. Additionally, we obtained major and trace element compositions and cosmic-ray exposure (CRE) ages of howardites to identify the geochemical characteristics of each howardite sample and to determine the ejection timing from the parent body.

Five howardites, Northwest Africa (NWA) 1929, NWA 6920, Yamato (Y) -7308, Y-000428, and Y-003125, were used in this study. Textual observations were performed by field emission-electron probe micro analysis (FE-EPMA). The major and trace element compositions of bulk samples (~50 mg) were measured with inductively coupled plasma-mass spectrometry (ICP-MS). All noble gas compositions were measured using a noble gas mass spectrometer, modified-VG5400/MS-3, with a sample amount of ~200 mg.

The proportion of eucrite and diogenite that contributed to the howardite samples were estimated by using the Al and Ca contents in individual howardites with an assumption that the two end-members are represented by a basaltic eucrite Juvinas and a diogenite Tatahouine. The five howardites are composed of basaltic eucrite and diogenite with a proportion of 95:5 for NWA 1929, 47:53 for NWA 6920, 39:61 for Y-000428, 37:63 for Y-003125, and 22:78 for Y-7308.

NWA 6920 and Y-003125 yielded the ^{244}Pu-Xe ages of ~4550 Ma, which corresponds to the timing of the initial crystallization of eucritic crust or global crustal metamorphism that were deduced from the of zircon ages of basaltic eucrites (e.g., Misawa et al., 2005; Iizuka et al., 2015). In contrast, younger ^{244}Pu-Xe ages (~4470 Ma) were obtained from NWA 1929, Y-7308, and Y-000428, indicating the timing of high-temperature reheating possibly due to impact events. The ^{40}K-^{40}Ar ages of NWA 1929, NWA 6920, and Y-003125 are 3.6 ±0.2, 3.6 ±0.2, and 3.2 ±0.2 Ga, respectively, which are consistent with the ^{39}Ar-^{40}Ar ages of brecciated eucrites (3.3–4.1 Ga; Bogard, 2011). The ages obtained in this study represent the timing of reheating by impacts, which reached a temperature above ~300 ℃, after the initial magmatism of eucritic crust. The (U-Th)/He ages of NWA 1929, NWA 6920, and Y-003125 are 2.3 ±0.2, 0.8 ±0.1, and 2.3 ±0.2 Ga, respectively. The (U-Th)/He systematics in the howardites could have been disturbed by degassing events that occurred at some points during the ejection from Vesta and delivery to the Earth, in addition to the impact events on Vesta. Some HED (Howardite-Eucrite-Diogenite) meteorites are considered to have derived from vestoids that were ejected from the Vesta's south pole craters (e.g., Clenet et al., 2014). Because the (U-Th)/He age of NWA 6920 is in good agreement with the age of the southern crater Rheasilvia (1.0 ±0.2 Ga, Schenk et al., 2012), NWA 6920 might have been severely suffered from the impact event that formed the Rheasilvia crater. The ^{81}Kr-Kr CRE ages vary from ~10 to

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45 Ma, which is consistent with the previously reported CRE ages of howardites (~11–76 Ma, Eugster and Michel, 1995). Since the CRE ages of howardites cluster at the same period to those of eucrites and diogenites, the HED meteorite clan might have been launched from vestoids or Vestan surface at the same time.

Keywords: Howardite, noble gas, chronology

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Non-destructive elemental analysis of a carbonaceous chondrite with direct current Muon beam at MuSIC

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Electron- or X-ray-induced characteristic X-ray analysis has been widely used to determine chemical compositions of materials in vast research fields. In recent years, analysis of characteristic X-rays from muonic atoms, in which a muon is captured, has attracted attention because both a muon beam and a muon-induced characteristic X-ray have high transmission abilities. Here we report the first nondestructive elemental analysis of a carbonaceous chondrite using one of the world-leading intense direct current muon beam source (MuSIC; MUon Science Innovative Channel). We successfully detected characteristic muonic X-rays of Mg, Si, Fe, O, S and C from CI chondrite, of which carbon content is about 3 wt%. Because of its high sensitivity to carbon, non-destructive elemental analysis with a muon beam can be a novel powerful tool to characterize future retuned samples from carbonaceous asteroids.

Keywords: muon, non-destructive elemental analysis, Hayabusa2

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Nucleosynthetic Sr and Nd isotopic anomalies of bulk differentiated meteorites

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Nucleosynthetic isotope anomalies have been discovered in bulk meteorites for refractory heavy elements (e.g., Cr, Ru [1, 2]). In the most cases, the extent of isotope anomalies is variable across different types of meteorites. These results point to the existence of planetary-scale isotope heterogeneities, which are most likely caused by the heterogeneous distribution of presolar dust grains in the early Solar System.

Although nucleosynthetic isotopic anomalies of bulk chondrites have been extensively studied in the last decade (e.g., [3]), the high-precision isotopic data of trans-iron elements in differentiated meteorites are still limited. Commonly, the parent bodies of differentiated meteorites possessed earlier accretional ages than those of chondrites. The comparison for the nucleosynthetic isotopic anomalies between chondrites and differentiated meteorites must provide vital information for understanding the physicochemical evolution of the early Solar System. Here we focus on refractory lithophile elements (Sr and Nd), whose carrier grains are silicate dust grains that were main constituents in the protoplanetary disk. In this study, we report high precision Sr and Nd isotope data of bulk differentiated meteorites.

We investigated two eucrites (Béréba and Millbillillie), an aubrite (Norton County), and an angrite (D'Orbigny). Powdered samples were treated with H_2O and distilled acetone to reduce the effects of terrestrial alteration. Subsequently, these meteorite samples were digested with HF and HNO_3 under high temperature and high pressure using a high pressure digestion system (DAB-2, Berghof). After the high-pressure digestion, samples were dissolved with $HClO_4$ and HNO_3. For Sr and Nd isotope analysis, a 5-step column separation procedure was conducted. Sr and Nd isotopic compositions were measured with TIMS (Triton *Plus*). Sr and Nd isotopic ratio measurements were conducted with the 2-line and 3-line dynamic multi-collection methods, respectively, in which $^{84}Sr/^{86}Sr$, $^{142}Nd/^{144}Nd$, $^{143}Nd/^{144}Nd$, $^{145}Nd/^{144}Nd$, $^{148}Nd/^{144}Nd$, and $^{150}Nd/^{144}Nd$ ratios can be obtained by reducing the effect of Faraday cup deterioration. The Sr and Nd isotope ratios are reported in the μM notation that is parts par 10^6 relative deviations from the terrestrial rocks.

Most of the samples we measured showed Sr and Nd isotopic ratios indistinguishable from the terrestrial rocks. Béréba (eucrite) possessed the most deviated isotopic compositions from the terrestrial rocks (μ^{84}Sr = 16 ±24 ppm, μ^{145}Nd = 5.5 ±1.9 ppm, μ^{148}Nd = 9.6 ±11 ppm, and μ^{150}Nd = 9.4 ±22 ppm, 2SDs). The inconsistency of the isotopic compositions for the same meteorite group (Béréba and Millbillillie) would be attributed to the possible terrestrial alteration for Millbillillie [4].

The nucleosynthetic Sr and Nd isotope anomalies for Béréba were indistinguishable from the data for non-carbonaceous meteorites (enstatite and ordinary chondrites) [3]. In the μ^{84}Sr versus $\mu^{145, 148, 150}$Nd diagrams, Béréba are plotted on the mixing line of the isotopic compositions for terrestrial rocks and presolar SiC [5]. These data imply that the parent bodies for enstatite chondrites, ordinary chondrites, and eucrites were formed within homogeneous isotopic reservoir with respect to Sr and Nd in which a part of building blocks of the Earth were not formed.

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Keywords: early Solar System, isotopic heterogeneity, achondrites

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[J] Oral | M (Multidisciplinary and Interdisciplinary)：M-TT Technology & Techniques

Sun. May 26, 2019 1:45 PM - 3:15 PM JST | Sun. May 26, 2019 4:45 AM - 6:15 AM UTC | 201A 2F

[M-TT48] Frontiers in Geochemistry

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Tetsuya Yokoyama(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Hajime Obata(Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo), Chairperson:Hirochika Sumino, Hajime Obata(Atmosphere and Ocean Research Institute, University of Tokyo), Tetsuya Yokoyama(Tokyo Institute of Technology)

In modern earth and planetary sciences, many new findings have been obtained by using state-of-the-art technique. These new findings include highly precise and accurate data, which is supported by recent developments of the new analytical methods. To use these data correctly and effectively, we need to deepen our knowledge on the methodology. This session aims at providing an opportunity for various geoscientists to get together and have a strategic discussion on frontiers in geochemistry and cosmochemistry. Especially, researchers, who would like to apply such innovative techniques, will have chances to discuss with those who work on devising new geochemical methods. We welcome a wide range of cutting-edge geochemical topics, including technical development, which have a potential for breakthrough of earth and planetary sciences. Any presentations related to the direction of geochemistry and cosmochemistry in future are also welcome. We expect wide-ranged and future-oriented discussion to develop geochemistry and cosmochemistry.

1:45 PM - 2:00 PM JST | 4:45 AM - 5:00 AM UTC

[MTT48-01] Data science approaches to geochemical data analysis

★Invited Papers

*Kenta Ueki[1] (1.Japan Agency for Marine-Earth Science and Technology)

2:00 PM - 2:15 PM JST | 5:00 AM - 5:15 AM UTC

[MTT48-02] Rapid *in situ* analyses of hydrogen and sulfur isotope ratios in basaltic glass by SIMS and their appilications

*Kenji Shimizu[1], Takayuki Ushikubo[1], Tomokazu Murai[2], Fumihiro Matsuura[2], Yuichiro Ueno[2] (1.Kochi Core Center, Japan Agency for Marine-Earth Science and Technology, 2.Tokyo Institute of Technology)

2:15 PM - 2:30 PM JST | 5:15 AM - 5:30 AM UTC

[MTT48-03] Determination of siderophile elements in metallic materials using multiple spot laser ablation-ICP-MS technique

*Yoshiki Makino[1], Yasuo Kuroki[2], Takafumi Hirata[1] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.Thermo Fisher Scientific)

2:30 PM - 2:45 PM JST | 5:30 AM - 5:45 AM UTC

[MTT48-04] Iron isotopic compositions of Luna 16, 20, 24 soils

★Invited Papers

*Satoki Okabayashi[1], Tetsuya Yokoyama[1], Takafumi Hirata[2], Kazuo Terakado[3], Erick M. Galimov[4] (1.Tokyo Institute of Technology, 2.The University of Tokyo, 3.Japan Space Forum, 4.Russian Academy of Science)

2:45 PM - 3:00 PM JST | 5:45 AM - 6:00 AM UTC

[MTT48-05] Synthesis of calcite reference materials for *in situ* U–Pb dating through crystallization from amorphous calcium carbonates

*Yusuke Miyajima[1], Ayaka Saito[1], Hiroyuki Kagi[1], Tatsunori Yokoyama[2], Takafumi Hirata[1] (1.Geochemical Research Center, Graduate School of Science, The University of Tokyo, 2.Tono Geoscience Center, Japan Atomic Energy Agency (JAEA))

3:00 PM - 3:15 PM JST | 6:00 AM - 6:15 AM UTC

[MTT48-06] Magnetic mapping of a speleothem from the southern Pacific with a scanning SQUID microscopy and its magnetic mineralogy

*Naoto Fukuyo[1,2], Hirokuni Oda[3], Yusuke Yokoyama[1,2], Geoffrey Clark[4], Yuhji Yamamoto[5] (1.Atmosphere and Ocean Research Institute, The University of Tokyo, 2.Department of Earth and Planetary Science, The University of Tokyo, 3.Institute of Geology and Geoinformation, 4.College of Asia and the Pacific,The Australian National University, 5.Center for Advanced Marine Core Research, Kochi University)

Data science approaches to geochemical data analysis

*Kenta Ueki[1]

1. Japan Agency for Marine-Earth Science and Technology

"Data science approaches" such as machine learning, multivariate statistical analysis, and artificial intelligence, are rapidly developing in various fields based on the recent advances in measurement techniques, rapid enhancement of database and improvement in computing power. Such data science approaches are increasingly being used in the Earth sciences. Geochemical data is high-dimensional and complex data of multivariate and multiple samples. By using the data science method, we can extract the fundamental structure or pattern from the high-dimensional geochemical data, and can evaluate the geological processes to derive the geochemical variations. We will present our recent results of the geochemical studies based on data science approaches, such as machine-learning-based geochemical tectonic discrimination and feature selection of global volcanic rocks, and stochastic crustal compositional model of the Japanese crust. In addition, we will discuss the future possibility of data science approach in the geochemistry.

Keywords: Data science, Geochemical data

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Rapid *in situ* analyses of hydrogen and sulfur isotope ratios in basaltic glass by SIMS and their appilications

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1. Kochi Core Center, Japan Agency for Marine-Earth Science and Technology, 2. Tokyo Institute of Technology

We developed rapid and accurate *in situ* analyses of hydrogen and sulfur isotope ratios of basaltic glass using high-resolution, multi-collection secondary ion mass spectrometry (CAMECA IMS-1280HR). Hydrogen and sulfur isotopes of standard basaltic glasses were determined by a high-temperature conversion elemental analyzer/isotope ratio mass spectrometer (IRMS) and IRMS, respectively. For the *in situ* analysis of sulfur isotopes, a defocused Cs beam (~0.5 nA; ~10 μm diameter) was used, but for hydrogen isotopes, we used a larger defocused beam (~5 nA; ~15 μm diameter) to decrease the hydrogen background. For analyses of D/H ($^{34}S/^{32}S$) ratios, ^{16}OH (^{32}S) and ^{16}OD (^{34}S) were measured in multi-detection mode with a Faraday cup and an axial electron multiplier, respectively. Each measurement lasted 6–7 minutes. Precisions (2 standard errors) for D/H and $^{34}S/^{32}S$ ratios were ~6 ‰(H_2O > 1 wt%) and ~0.6 ‰(S > 1000 ppm), respectively. Our developed method for rapid and high spatial resolution analysis can determine concentrations of volatiles, hydrogen and sulfur isotopes in a single small melt inclusion of ~30 μm diameter. Using this method, we analyzed hydrogen and sulfur isotope ratios of submarine basaltic glasses from mid-oceanic ridges and oceanic islands of Hawaii and confirmed that their D/H and S isotope ratios were consistent with reported values.

Keywords: SIMS, hydrogen isotope, sulfur isotope, basaltic glass

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Determination of siderophile elements in metallic materials using multiple spot laser ablation-ICP-MS technique

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Abundances of siderophile elements in metallic phase of the meteorites can provide various cosmochemical information for the formation sequence of the core formation on the small planets including planetesimals[1]. Among the siderophile elements, fractionation pattern of Mo and W relative to other refractory siderophiles of similar volatility (Re, Os, Ir, Ru, Pt) reflects the oxygen fugacity or the partial pressure of oxygen in early solar system[2]. Despite this, sensitive and precise elemental analysis on metallic materials have been retarded mainly due to analytical difficulties, originating from low concentration of the elements and matrix effects.

Laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) has been used as a method to directly determine trace elemental composition in a metallic iron[3, 4]. With the LA-ICP-MS technique, multi-element determinations for trace-elements can be achieved. Moreover, with the newly developed multiple spot laser ablation protocol, elemental sensitivity and analysis repeatability can be further improved, and now the elemental determinations for trace-elements with concentrations of lower than ng g^{-1} can be made.

One of the major analytical difficulty to obtain reliable abundance data for analytes would be the availability of calibration standard with proper concentration ranges. This is the main reason why resulting abundance values for the trace-elements became erroneous. Faced with this, we have developed new analytical protocol using multi-spot laser ablation technique using a Galvanometric optics (msLA-ICP-MS). With the multiple spot ablation, two or more solid samples can be ablated almost at a same time, and the laser ablation induced sample aerosol could be mixed and introduced into the ICP-MS, suggesting that mixing, dilution of analytes, and spiking of second elements can be made just like a treatment of solution samples. This suggests that concentration ranges of the analytes can be adjusted, and therefore, the ranges of the calibration curve can be fit to the concentration range of the analytes.

In this study, present msLA-ICP-MS was applied for elemental determinations of 35 trace elements (B, C, Mg, Al, Si, P, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, Ga, Ge, As, Zr, Nb, Mo, Ru, Rh, Pd, Sn, Sb, La, Ce, Ta, W, Re, Os, Ir, Pt, Pb) in 13 various metallic materials (iron meteorite, low alloy steel, stainless steel, tool steel). Hence, concentration range for the analytes were adjusted by mixing two standard materials (JSS 654 stainless steel and Hoba IV iron meteorite). To evaluate the accuracy of the measurements, abundances of Cr in various materials were measured by the msLA-ICP-MS technique. The resulting abundance values for Cr was 7080±120 $\mu g\ g^{-1}$ for NIST SRM 661 (low alloy steel), 15.78±0.41 % for JSS 650 (stainless steel), 23270±430 $\mu g\ g^{-1}$ for JSS 603 (tool steel). These results exhibited good agreement with the literature values within 5 %. The detection limit calculated from the calibration curve is about 1 $\mu g\ g^{-1}$, thus the measurement with about 6 orders of magnitude in dynamic range could be made. The precision of the measurements defined by repeatability of the measurements from 5 times repeated analysis was better than 3 %. The precision and accuracy of the results obtained by the msLA-ICP-MS technique were comparable to those obtained by the solution based ICP-MS. In addition, similar accuracy and precision were obtained for other trace elements acquired simultaneously.

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These data obtained here clearly demonstrate that msLA-ICP-MS can become a powerful tool for elemental analysis in solid samples. In this presentation, we will describe both the principle of msLA-ICP-MS and its application for the trace elemental analysis in metallic irons.

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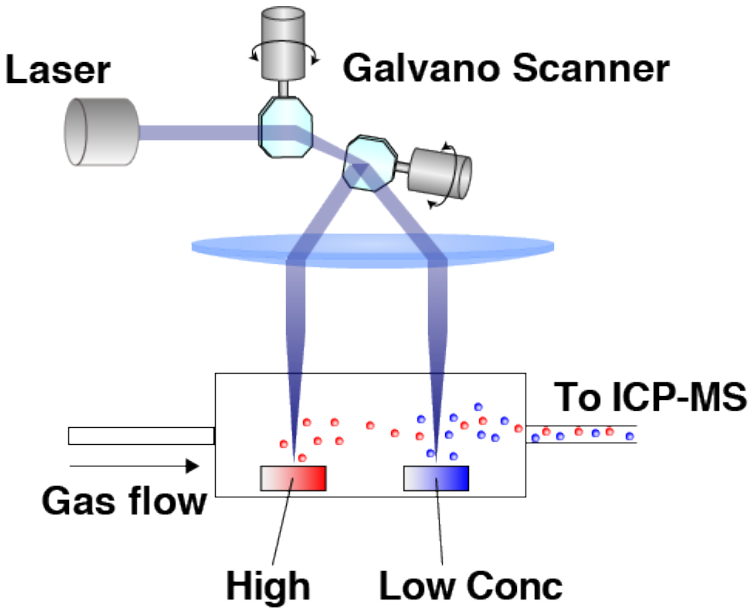
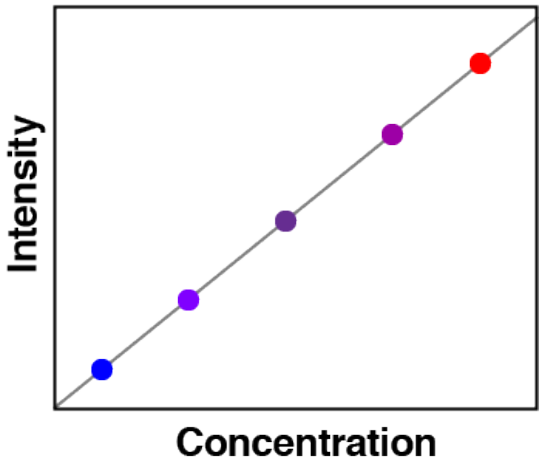
Keywords: cosmochemistry, LA-ICP-MS, trace element, metal, siderophile element, meteorite





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Iron isotopic compositions of Luna 16, 20, 24 soils

*Satoki Okabayashi[1], Tetsuya Yokoyama[1], Takafumi Hirata[2], Kazuo Terakado[3], Erick M. Galimov[4]

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Iron is one of the most abundant elements in the Moon. The Fe exhibits not only siderophile property but also lithophile and chalcophile properties, thus, it is included in most of the minerals and rocks that compose the Moon. Therefore, Fe isotopic composition of the Moon potentially record the fractionation process that occurred during the formation of the Moon and the differentiation or alteration after the Moon formation. Previous works on Fe isotopic analyses of lunar samples suggested that the observed Fe isotopic compositions record fractionation during evaporation of Fe related to giant impact [1], differentiation of lunar magma ocean [2]–[4], and space weathering [5]–[7].

At present, there are no lunar meteorites collected as fall, thus, returned samples of the Moon are important for lunar Fe isotopic studies. In this study, we have measured Fe isotopic ratios of soil samples from the Soviet Luna missions, Luna 16, 20, and 24, using MC-ICP-MS. A highly matured sample from Luna 16 shows clearly distinguished Fe isotopic compositions between the fine-grain and coarse-grain fractions, while such Fe isotopic discrepancies among different size fractions were much smaller in submature (Luna 20) and immature (Luna 24) samples. The Fe isotopic ratios of separated grains show that agglutinates have higher δ^{57}Fe values than the bulk and monomineralic grains, indicating the abundant np-Fe^0s in agglutinates and the partial evaporation of Fe during its melting.

The δ^{57}Fe value for the coarsest grain fraction of very low-Ti basalt from Luna 24 was found to be 0.08 ± 0.04‰, which is the first Fe isotopic composition reported for very low-Ti mare basalts. This value is clearly lower than previously reported δ^{57}Fe values for high-Ti and low-Ti basalts, and is nearly identical to those of Mg-suites. This observation is consistent with the Fe isotopic evolution model during differentiation of lunar magma ocean [3]. Furthermore, the Fe isotopic ratio of the very low-Ti basalt is indistinguishable from that of the Earth’ s mantle, thus, the bulk silicate Earth and Moon are considered to possess an identical or very close Fe isotopic composition.

References: [1] Poitrasson et al. (2009), *EPSL, 223*, 253-266. [2] Liu et al. (2010), *GCA, 74*, 6249-6262. [3] Sossi and Moynier (2017), *EPSL, 471*, 125-135. [4] Wang et al. (2015), *EPSL, 430*, 202-208. [5] Wiesli et al. (2003), *EPSL, 216*, 457-465. [6] Moynier et al. (2006), *GCA, 70*, 6103-6117. [7] Wang et al. (2012), *EPSL, 337-338*, 17-24.

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Synthesis of calcite reference materials for *in situ* U–Pb dating through crystallization from amorphous calcium carbonates

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Calcium carbonates are ubiquitously present throughout the Earth history as animal shells, speleothems, fault-related vein fillings, and hydrothermal or cold-seep precipitates. Direct dating of carbonates provides valuable information on paleoenvironmental change, tectonics, and fluid and material cycling. Uranium–lead (U–Pb) dating using high spatial-resolution laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) is a key technique to date natural carbonates such as fault-hosted calcite that cannot be dated by biostratigraphy or Sr isotope stratigraphy (Roberts and Walker, 2016; Beaudoin et al., 2018). *In situ* U–Pb dating by LA-ICP-MS needs matrix-matched reference materials to correct matrix-dependent elemental fractionation in LA-ICP-MS. Roberts et al. (2017) demonstrated that a natural calcite cement WC-1 (254.4 ±6.4 Ma) is suitable as a calcite reference material. However, the WC-1 calcite has an inhomogeneous distribution of U and Pb and lacks concordance in the U–Pb system (Roberts et al., 2017). In this study, we synthesized novel calcite reference materials with homogeneous U and Pb concentrations and isotope ratios. Incompatible elements such as Sr can be incorporated into calcite through pressure- or heat-induced crystallization from amorphous calcium carbonate (ACC) precipitated from element-doped reagent solution (Matsunuma et al., 2014; Saito et al., 2017). We incorporated U and Pb into calcite through heat-induced crystallization from U, Pb-doped ACC. The homogeneity of the U/Ca and Pb/Ca ratios in the synthetic calcite examined with LA-quadrupole (Q)-ICP-MS was generally better than 8% and 13%, respectively, in relative standard deviation (2SD, n = 10). The $^{207}Pb/^{206}Pb$ ratio of the synthetic calcite measured with LA-multiple-collector (MC)-ICP-MS was homogeneous within ~1% errors, whereas the $^{238}U/^{206}Pb$ ratio was less homogeneous (3%–11% errors). The inhomogeneity in the U/Pb isotope ratio would be propagated into the analytical precision for unknown samples. In order to test the usability of the synthetic calcite, we dated WC-1 using the synthetic calcite for correction of elemental fractionation. We calculated the nominal $^{238}U/^{206}Pb$ ratio in the synthetic calcite from its U and Pb concentrations measured by LA-Q-ICP-MS using Ca as an internal standard. We then obtained the fractionation factor to correct bias between the isotope ratios measured by LA-MC-ICP-MS and the nominal value. Using the fractionation factor, we could accurately date WC-1 with an ~3% precision (246.6 ±7.3 Ma). If the isotopic compositions of the synthetic calcite are certified by isotope-dilution technique, we could date natural carbonates with <10% precisions using the synthetic reference calcite.

Keywords: Amorphous calcium carbonate, LA-ICP-MS, Reference material, U–Pb geochronology

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Magnetic mapping of a speleothem from the southern Pacific with a scanning SQUID microscopy and its magnetic mineralogy

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Speleothems can be an ideal record of paleomagnetism since they retain continuous geomagnetic records in stable condition as well as having applicability of high-precision radiometric dating via U-series and radiocarbon techniques. Although their weak magnetic signals hinder this archive to be widely used in the field, Lascu et al. (2016) successfully reconstructed paleomagnetic signatures during the Laschamp excursion from a stalagmite. A scanning SQUID Microscope (SSM) can image very weak magnetic fields at high spatial resolution, and hence could potentially solve this obstacle. However, only a primitive paleomagnetic mapping without interpretation has been made on a speleothem using SSM (Myre et al., 2019). In this study, we have conducted magnetic imagings at submillimeter scale with an SSM at Geological Survey of Japan, AIST on a speleothem collected at Anahulu cave in Tongatapu Island, the Kingdom of Tonga. The ^{14}C age of the surface part of the stalagmite is around 10 ka. The stalagmite block samples were cut perpendicular to the growing direction and shaped to a thickness of ca.0.2 mm before measurements with the SSM. The measured magnetic field is ~±1.5 nT at a senor-to-sample distance of ~200 μm. In association with the laminated structures of the speleothem, we observe stronger magnetic field for the surface layer compared with that of the inner layers. Furthermore, we conducted several magnetic experiments; i.e. first-order reversal curve (FORC) measurements, and low temperature magnetometry. We also conducted decomposition of Isothermal Remanent Magnetization (IRM) acquisition curves at a room temperature and a temperature below Verwey transition. These results show that the speleothem contains a mixture of magnetite and maghemite with different magnetic domain states. The proportion of magnetite and maghemite are shown to be different between the surface layer and the inner layers. These observations are consistent with the magnetic image of a rock magnetic parameter representing coercivity (S-ratio) calculated by inversion of a series of IRM measurements with the SSM.

Keywords: Scanning SQUID microscopy, paleomagnetism, speleothem

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[J] Oral | M (Multidisciplinary and Interdisciplinary) : M-TT Technology & Techniques

Sun. May 26, 2019 3:30 PM - 5:00 PM JST | Sun. May 26, 2019 6:30 AM - 8:00 AM UTC | 201A 2F

[M-TT48] Frontiers in Geochemistry

convener:Hirochika Sumino(Department of Basic Science, Graduate School of Arts and Sciences, The University of Tokyo), Tetsuya Yokoyama(Department of Earth and Planetary Sciences, School of Science, Tokyo Institute of Technology), Hajime Obata(Marine inorganic chemistry division, Atmosphere and Ocean Research Institute, University of Tokyo), Chairperson:Hirochika Sumino, Hajime Obata(Atmosphere and Ocean Research Institute, University of Tokyo), Tetsuya Yokoyama(Tokyo Institute of Technology)

In modern earth and planetary sciences, many new findings have been obtained by using state-of-the-art technique. These new findings include highly precise and accurate data, which is supported by recent developments of the new analytical methods. To use these data correctly and effectively, we need to deepen our knowledge on the methodology. This session aims at providing an opportunity for various geoscientists to get together and have a strategic discussion on frontiers in geochemistry and cosmochemistry. Especially, researchers, who would like to apply such innovative techniques, will have chances to discuss with those who work on devising new geochemical methods. We welcome a wide range of cutting-edge geochemical topics, including technical development, which have a potential for breakthrough of earth and planetary sciences. Any presentations related to the direction of geochemistry and cosmochemistry in future are also welcome. We expect wide-ranged and future-oriented discussion to develop geochemistry and cosmochemistry.

3:30 PM - 3:45 PM JST | 6:30 AM - 6:45 AM UTC

[MTT48-07] Uptake and accumulation of methylmercury by marine phytoplankton

★Invited Papers

*Yuya Tada[1], Kohji Marumoto[1] (1. National Institute For Minamata Disease)

3:45 PM - 4:00 PM JST | 6:45 AM - 7:00 AM UTC

[MTT48-08] A protocol for simultaneous analysis of archaeal core and intact polar lipids using normal-phase HPLC/ESI-MS

*Shunsuke Horai[1], Hiroshi Naraoka[1,2] (1.Kyushu University, 2.Research Center for Planetary Trace Organic Compounds)

4:00 PM - 4:15 PM JST | 7:00 AM - 7:15 AM UTC

[MTT48-09] Assessment of Northeastern Japan Tree-Ring Oxygen Isotopes for Reconstructing Early Summer Hydroclimate and Spring Arctic Oscillation

*Wataru Sakashita[1,2,3], Yusuke Yokoyama[3], Hiroko Miyahara[2], Takahiro AZE[3], Stephen Obrochta[4], Motonari Ohyama[5], Hitoshi Yonenobu[6] (1.Forestry and Forest Products Research Institute, 2.Musashino Art University, 3.Atmosphere and Ocean Research Institute, The University of Tokyo, 4.Akita Univeristy, 5.Tohoku University, 6.Naruto University of Education)

4:15 PM - 4:30 PM JST | 7:15 AM - 7:30 AM UTC

[MTT48-10] **Development of the rotational diamond anvil cell for high-pressure deformation experiments and its measurement systems**

★Invited Papers

*Shintaro Azuma[1,2], Ryuichi Nomura[3,4], Kentaro Uesugi[5], Yu Nishihara[4], Doi Shunta[4], Takeshi Arimoto[4], Tetsuo Irifune[4] (1.Tokyo Tech., 2.Kyushu Univ., 3.Kyoto Univ., 4.Ehime Univ., 5.JASRI)

4:30 PM - 4:45 PM JST | 7:30 AM - 7:45 AM UTC

[MTT48-11] Speciation of metal ions in hydrosphere: Further classification of intermediately hard ligands in HSAB theory

*Makoto Nagasawa[1], Masato Tanaka[1], Asami Miyaji[2], Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Hiroshima University)

4:45 PM - 5:00 PM JST | 7:45 AM - 8:00 AM UTC

[MTT48-12] Difference in the partition behaviors and speciation between scandium and other rare earth elements in nickel laterite ore deposits

Haibo Qin[1], Kenzo Sanematsu[2], Arcilla Carlo[3], *Yoshio Takahashi[1] (1.Department of Earth and Planetary Science, Graduate School of Science, The University of Tokyo, 2.Institute for Geo-Resources and Environment, National Institute of Advanced Industrial Science and Technology (AIST), 3.National Institute of Geological Sciences, College of Science, University of the Philippines)

Uptake and accumulation of methylmercury by marine phytoplankton

*Yuya Tada[1], Kohji Marumoto[1]

1. National Institute For Minamata Disease

Introduction: Eating marine fish are the main source of the toxic and bioaccumulative methylmercury (MeHg) exposure in human. However, information about the accumulation process of MeHg through marine food webs is severely limited. Phytoplankton serve as a main entry for dissolved methylmercury (MeHg) into aquatic food webs. Thus, measuring uptake ratio and accumulation of MeHg by marine phytoplankton is critical for understanding mercury risks for marine organisms and human. To date, most research on the algal uptake of MeHg were conducted using freshwater phytoplankton, and there is few studies on marine species. In this study, we examined the uptake and accumulation of MeHg using 5 marine phytoplankton cultures affiliated with different algal lineages (2 diatoms, cyanobacteria, pelagophyte, and haptophyte), and evaluated that the differences of bioaccumulation between dead and live cells.

Materials and methods: Five axenic phytoplankton cultures *Thalassiosira pseudonana* (CCMP1335), *Thalassiosira oceanica* (CCMP1005), *Synechococcus* sp. (CCMP1334) *Pelagomonas calceolate* (CCMP1756), *Emiliania huxleyi* (CCMP374) were used for incubation experiments with MeHg addition. After preculture in L1 medium, all species were cultured axenically in the L1 medium with MeHg (ca. 1,000 pg / l) at 22ºC under light or light:dark (12 h: 12 h) conditions. Incubation time was varied from several hours (short term) to days (long term). During incubation experiments, we collected subsamples of cultures several times. Phytoplankton cells (particulate fraction) were collected using the GF-75 glass-fiber filter, and stored at -80 ºC until further analysis. Filtrate (dissolved fraction) was amended with H_2SO_4 and stored at 4 ºC. To evaluate the bioaccumulation of dead and live cells, we used the *T. pseudonana* cells killed by heating (100 ºC for 20 min). Particulate and dissolved MeHg concentration were analyzed using a combined technique of dithizone extraction and the EPA method 1630.

Results and discussion: Incubation experiments revealed that all phytoplankton cultures incorporated and accumulated MeHg during incubation. In addition, incorporated MeHg would not be released from phytoplankton cells during incubation experiment. Short term incubation experiments revealed that phytoplankton cells took up 60 to 87% of the amended MeHg within 1 hour. Cellular MeHg concentration varied among phytoplankton cultures, and those of *Synechococcus* sp. (0.1-0.2 ag MeHg / cell) were relatively lower than those of other cultures. Experiments using dead and live cells showed that MeHg concentrations of dead cells were obviously lower than those of live cells, suggesting that a active MeHg uptake for this culture. Our results suggest that phytoplankton cells could actively take up and accumulate MeHg, and bioaccumulation ratio varied among phytoplankton species.

Keywords: Marine, Methylmercury, phytoplankton

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A protocol for simultaneous analysis of archaeal core and intact polar lipids using normal-phase HPLC/ESI-MS

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Isoprenoidal glycerol core lipids (CLs) from archaeal cell membranes have been utilized as proxies for paleo-environmental reconstruction (e.g., Schouten et al., 2002), and their intact forms (i.e., intact polar lipids: IPLs) can provide information on *in situ* archaeal activities in natural ecosystems (e.g., Lipp et al., 2008). Each form has been analyzed with normal phase (NP)-HPLC/ESI-MS for IPLs (Sturt et al., 2004) and with NP-HPLC/APCI-MS for CLs (Hopmans et al., 2000; Schouten et al., 2007) after the sample preparation (i.e. pre-separation of the total lipid extract into a polar and an apolar fraction, followed by acid hydrolysis of the polar fraction). However, such analytical protocols require relatively large amount of sample with great time and effort for the sample preparation. Furthermore, the acid hydrolysis of polar head groups and the APCI often cause degradation of labile lipids (e.g., hydroxyarchaeol) and byproduct formation (Liu et al., 2012; Sprott et al., 1990; Koga and Morii, 2005).

To overcome these shortcomings of traditional lipid analysis, we developed a novel NP-HPLC/ESI-MS protocol for simultaneous characterization of the distribution of CLs and IPLs from total lipid extracts in one analytical run. In order to cover the broad range of archaeal lipids in natural samples, the chromatographic separation and MS detection were optimized using the total lipid extracts of archaeal cultures having greatly different lipid compositions (*Methanosarcina barkeri* and *Sulfolobus acidcaldarius*).

With this protocol, CLs were separated according to structural variation of the alkyl chains and subsequently IPLs according to polar head group polarity into individual lipid classes. The distinct partitioning of separation part of CLs and IPLs is an important advantage when screening archaeal lipids in complex natural samples. Moreover, hydroxyarchaeol and their intact polar derivatives, which were lost in the conventional NP-HPLC/APCI-MS protocol, were detected in the total lipid extract from *M. bakeri*.

We also compared the quantitative accuracy and sensitivity on the detection of CLs between APCI and ESI-MS by using core GDGTs isolated and purified from a culture of *S.acidcaldarius*. As a result, the relative distributions of core GDGTs with NP-HPLC/ESI-MS were similar to those when analyzing with NP-HPLC/APCI-MS. This result suggests that our protocol can be applied to the study of core GDGT-based environmental proxies.

In addition to development of this protocol, we plan to apply the simultaneously chromatographic separation of this protocol to the preparation for compound-specific isotope analysis and structural identification of archaeal lipids, which will contribute for the study of archaeal activities in the environment that sample amounts are limited.

Keywords: Archaea, Intact polar lipids (IPLs), Core lipids (CLs), Simultaneous analysis

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Assessment of Northeastern Japan Tree-Ring Oxygen Isotopes for Reconstructing Early Summer Hydroclimate and Spring Arctic Oscillation

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The spring Arctic Oscillation (AO) significantly affects the subsequent summer rainfall in the East Asian Summer Monsoon (EASM) region, and analysis of meteorological data indicates this teleconnection strength varied on interdecadal timescales during the late 20th century. Tree-ring records may be able to extend the relatively short observational record, but the extent to which these proxy reconstructions correspond to AO variability has yet to be explored in this region. Therefore, we present new tree-ring cellulose oxygen isotope ($\delta^{18}O$) records from northeastern Japan (Akita, northern limit of EASM), spanning AD 1950 to 2003 which overlaps with the instrumental record. Tree-ring $\delta^{18}O$ is used for reconstructing the past hydroclimate variability and allows us to consider whether tree-ring $\delta^{18}O$ has the potential to clarify the longer-term interdecadal changes in the spring AO-EASM relationship. Measurements and analyses show that our tree-ring $\delta^{18}O$ datasets have a significant negative correlation with May-June-July relative humidity, and the tree-ring $\delta^{18}O$ in northeastern Japan also significantly correlates with the summer EASM index. Temporal comparisons between our record and observed monthly AO index indicate that reconstructed following early summer relative humidity significantly correlates to the previous March-April-May AO. This linkage changes on interdecadal timescales, and the linkage is relatively strong during early 1970s through early 1990s. Similar results are also obtained using a separate tree-ring $\delta^{18}O$ record from a separate location about 200 km to the southeast, suggesting that tree-ring cellulose $\delta^{18}O$ in northeastern Japan is indeed useful for better understanding the long-term teleconnection between the spring AO and EASM.

Keywords: Tree-ring, Oxygen isotopes, Northeastern Japan, Arctic Oscillation, East Asian summer monsoon

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Development of the rotational diamond anvil cell for high-pressure deformation experiments and its measurement systems

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The mechanical properties of lower mantle materials are key to understanding the dynamics and evolution in the Earth’s interior. However, the pressure range of deformation apparatuses which can achieve large strain is limited to ~30–40 GPa due to a technical reason. We developed a new deformation apparatus named rotational diamond anvil cell (rDAC). This deformation apparatus can apply the torsional deformation to a sample, thus the rDAC can theoretically produces an infinite strain within the sample under ultra-high pressure conditions, corresponding to those of core-mantle boundary [Nomura et al., 2017]. The rDAC is the most suitable deformation apparatus with which to investigate the mechanical properties of deep-Earth materials. In this presentation, we will mainly present the measurement systems, technology and idea which were applied to the rDAC.

Deformation apparatuses used in Earth science need high-pressure and high-temperature techniques, the constant strain rate, and the measurement systems of the stress and strain. The rDAC can apply high pressure and torsional deformation to a sample with constant strain rate by a gearbox and diamond anvils with grooves [Azuma et al., 2018]. *In situ* strain measurements are conducted using X-ray laminography techniques at BL47XU, SPring-8 [Nomura and Uesugi, 2016]. High-temperature conditions and stress measurements have not been achieved in rDAC. Recently, however, the vacuum chamber newly designed for rDAC was installed for high temperature experiments, and stress measurements using X-ray Diffraction (XRD) were applied to deformation experiments in rDAC at SPring-8 (Japan).

To test the high temperature technique and stress measurements using XRD with the new vacuum chamber, the mixture of bridgmanite $(Mg,Fe)SiO_3$ and ferropericlase (Mg,Fe)O, which was synthesized from San Carlos olivine, was deformed under torsion geometry using the rDAC at BL47XU, SPring-8. The vacuum chamber has a removable Kapton window for incident and diffracted X-ray, and can keep the vacuum state (<~10 Pa) to prevent the diamond anvils from oxidation during high-temperature deformation experiments. Platinum wires were used as a resistance heater surrounding the sample and Rhenium gasket. Stress was measured by collecting X-ray diffraction pattern at twelve different azimuthal angles, Ψ= 0º, ±30º, ±60º, ±90º, ±120º, ±150º, and 180º.

In heating experiments using new vacuum chamber, temperature was monitored by Pt/Rh thermocouple placed close to the sample and we succeeded in increasing temperature up to ~1000 K. However, the resistance heater (Pt) was unstable in vacuum. In the future, high-temperature deformation experiments using rDAC will be performed in reducing atmosphere produced by inactive gas (e.g., Argon gas) or internal heating system should be developed for the rDAC .

Stress in bridgmanite was estimated by using diffraction peaks (110) and (112) at P= 50 GPa and T= 673 K. Shear stress in bridgmanite was relatively constant values, whereas uniaxial stress changed during deformation experiments. This preliminary experiment was performed under low-temperature and high-pressure conditions, thus the equivalent stress in bridgmanite was about three times higher than that in previous studies [e.g., Girard et al., 2016].

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Keywords: High pressure, Deformation, Diamond anvil cell

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Speciation of metal ions in hydrosphere: Further classification of intermediately hard ligands in HSAB theory

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Complexation of metal cations with oxygen donor ligands such as hydroxide ion, carbonate ion, phosphate ion, and carboxylate ion is one of the most important factors controlling their behaviors in hydrosphere. Turner (1981) classified these ligands as “intermediately hard ligands” in HSAB (hard and soft acids and bases) theory. However, we found that the reactivity of hydroxide ion greatly depends on cation’s ionic radius, which results in distinguishing this ligand from the other intermediately hard ligands. Taking divalent alkaline earth metal ions as an example, Mg^{2+} mainly precipitates as hydroxide (brucite), whereas Ca^{2+} prefers carbonate (calcite) or phosphate (apatite) to hydroxide, but quantitative discussion on the mechanism has not been performed.

In this study, we evaluated the standard Gibbs free energy change of reaction ($\Delta G^0_R = \Delta H^0_R - T\Delta S^0_R$) on the complexation of hydrated metal cations with above ligands, based on thermodynamic data. The results revealed that the entropic contribution to the stabilization was large for hydroxide complexes of smaller cations. Since the entropy in aqueous complexation reaction is controlled by the number of water molecules released to the solution possibly due to replacement of the water molecules by inner-sphere complexation, it is suggested that hydroxide complexes of larger cations are less stable due to the small effect of the dehydration.

In order to support this suggestion, we conducted quantum chemical calculation, using Gaussian 09. The distance between hydrated metal cation (M) and oxygen of ligand (O) was calculated for several ions. The results showed that the average M-O distance of hydroxide complex increased with the increase of cation’s ionic radius more remarkably than that of the other complexes such as carbonate ion. This means that hydroxide favors to form outer-sphere complex for larger cations, which is consistent with our suggestion based on the thermodynamic data.

Keywords: Speciation, HSAB theory, Quantum chemical calculation, Inner-sphere complex, Outer-sphere complex

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Difference in the partition behaviors and speciation between scandium and other rare earth elements in nickel laterite ore deposits

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Scandium (Sc) is a critical metal with wide applications in modern industrial applications. Consequently, the enrichment of Sc at earth surface has been of great interest in resource geology. It has been reported that laterite enriched with nickel (Ni laterite) contained significant amounts of Sc (about 80-100 ppm). The vertical profile of Ni laterite mainly consists of bed rock, saprolite, and limonite layers from bottom to the top. Generally speaking, Ni remobilized downward during weathering processes leads to the enrichment of Ni in the saprolite layer, while maximum Sc enrichment is found in the limonite layer mainly consisting of goethite. However, distribution and speciation of Sc in the limonite layer are not clear at present, which was examined by μ-XRF mapping and X-ray absorption fine structure (XAFS) spectroscopy in this study. In addition, similar information such as abundances and speciation was obtained also for other rare earth elements including yttrium (REY) to compare geochemical behaviors between Sc and REY.

Micro-XRF analysis revealed that Sc and Y are distributed to goethite in the limonite layer. Sequential extraction revealed that Sc remains in the residual phase which goethite is still present even after the treatments by reducing agents and aqua regia. XANES and EXAFS analyses for Sc in the limonite layer and its comparison with synthetic samples of Sc coprecipitated with goethite and Sc adsorbed on goethite revealed that Sc was incorporated within the goethite structure replacing Fe^{3+} site. This result is reasonable considering the similar ionic radii (6 coordination number) of Sc^{3+} (0.75 Å) and Fe^{3+} (0.65 Å). On the contrary, EXAFS for the Y samples synthesized similarly to Sc showed that Y cannot be incorporated within the goethite structure, possibly due to its large size (ionic radius of Y^{3+}: 0.90 Å) compared with Fe^{3+}. The sequential extraction showed that most of Y was present as ion-exchangeable species or Y in amorphous Fe and Mn oxides, which are consistent with the fact that Y is mainly present as adsorbed species on goethite. These results clearly explain fractionation of REY and Sc in limonite layer, with steep increase from Yb^{3+} to Sc^{3+} when we plot Sc at right of Lu in REY pattern.

The high concentration of Sc in Ni laterite is caused by (i) high concentration of Sc in the original rock (peridotite) and (ii) effective fixation of Sc^{3+} within goethite by substitution of Fe^{3+} site by Sc^{3+} during intense weathering to form laterite.

Keywords: scandium, rare earth elements, laterite

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